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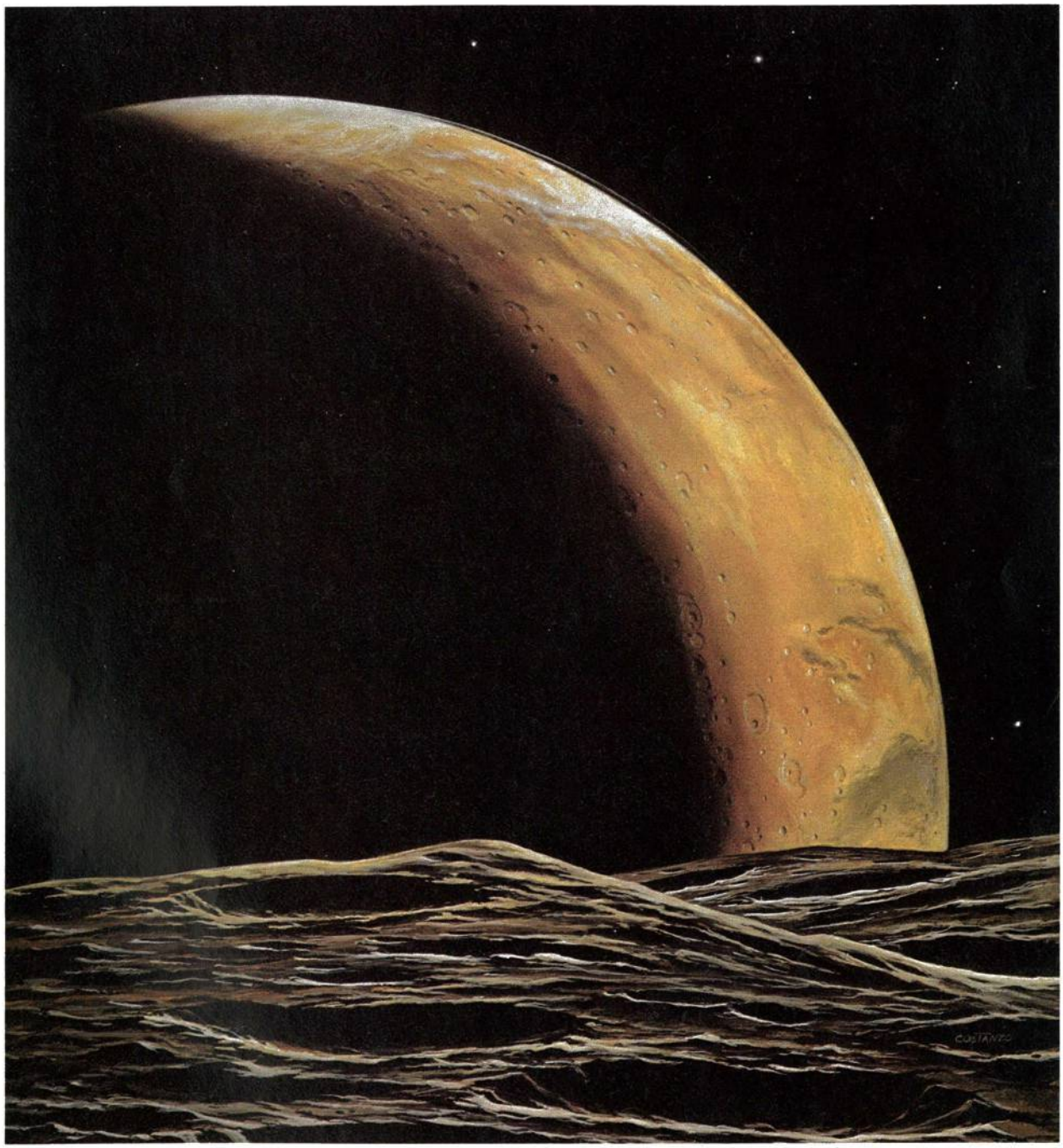

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ASTRONOMY

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(Cover) Crescent Mars over Phobos

Mars sits permanently over the Phobos horizon as the tiny moonlet revolves around Mars and keeps its same face to the primary. Mars would appear to wax and wane as it remains stationary to an observer from Phobos. Here, Solis Lacus is coming into view as Phobos speeds along its orbit. While the North Pole and icecap are not visible from this close a vantage point, the North Polar Hood can be seen as low-lying clouds and blue haze. The 30 mile high haze layer appears as a well-defined line above the limb of Mars near the Polar Hood.

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Original painting for ASTRONOMY by Victor Costanzo

The Hurtling Moons of BARSOOM

by

Carl Sagan

Dr. Carl Sagan is director of the Laboratory for Planetary Studies at Cornell University and is probably the world's foremost authority on the planet Mars. This article is a chapter from Dr. Sagan's most recent book, **The Cosmic Connection: An Extraterrestrial Perspective,** Copyright ©1973 by Carl Sagan and Jerome Agel, to be published in November by Doubleday & Company, Inc.

In my boyhood I was lucky enough to come upon a set of turgidly written novels with names like **Thuvia, Maid of Mars, The Chessman of Mars, The Princess of Mars, The Warlords of Mars,** and so on. They were, needless to say, about Mars. They were not about "our" Mars — the Mars revealed by Mariner 9.

At least I don't think our Mars is like the Mars of these novels by Edgar Rice Burroughs, the inventor of Tarzan. His Mars was Percival Lowell's Mars — a planet of ancient sea bottoms, working canals and pumping stations, six-legged beasts of burden, and men (some headless) of all colors, including green. They had names like Tars Tarkas. Possibly the most remarkable hypothesis proposed by Burroughs in these novels was that human beings and inhabitants of Mars could produce live offspring — a biologically impossible proposition if the Martians and we are imagined as having separate biological origins. Burroughs wrote decorously of the inter-fertility of a Virginian miraculously transported to Mars and Dejah Thoris, the princess of a kingdom with the improbable name of Helium. I have little doubt that the precedent of a kingdom called Helium led directly to the planet called Krypton, home of the comic book hero Superman. There is here a rich vein of untapped literary ore. The future may hold planets, stars, or even entire galaxies named Neon, Argon, Xenon, and Radon — the remaining noble gases.

But the name invented by Burroughs that has haunted me across the years is the name he imagined the Martians gave to Mars: Barsoom. And it was one phrase of his more than any other that captured my imagination: "the hurtling moons of Barsoom".

For Mars is indeed a world with two moons — a situation that would appear to the inhabitants of Mars as entirely natural as our one moon does to us. We know how our solitary satellite looks to the naked eye from the surface of Earth. But what do the moons of Barsoom look like from the surface of Mars? This question, which intermittently plagued my boyhood, was not to be answered until 1971 and Mariner 9.

Looking from the orbit of Deimos toward Mars (left), the areas of Syrtis Major and Sabaeus Sinus are under a high sun while Meridiani Sinus is in early morning and Margaritifer Sinus is experiencing sunrise. The South Polar cap is at bottom, while the North cap is occulted by the seven mile wide Deimos. Phobos, 9,000 miles closer in towards Mars, shows its oblong shape to the left of the sunrise line as it orbits along the equatorial plane of Mars.

The moons of Mars were invented by Johannes Kepler, the discoverer of the laws of planetary motion and no intellectual lightweight. But he lived in the 16th century, in a different intellectual climate from the present. He cast horoscopes for a living; astronomy was his passion more than his occupation. His mother was tried as a witch. When Kepler learned of Galileo's discovery, with one of the first astronomical telescopes, of the four large moons of Jupiter, he immediately concluded that Mars had two moons. Why? Because Mars was at an intermediate distance from the Sun, between Earth and Jupiter. It must obviously have an intermediate number of moons. The observations seemed to show Venus with no moons, Earth with one, and Jupiter with four (the actual number, we now know, is 12). Kepler could have deduced either two or three moons for Mars. But bearing a lifelong passion for geometrical progressions, he chose two. The argument is of course fallacious. Saturn's 10 moons, Uranus five and Neptune's two in no way fit his scheme, which is not scientific but aesthetic.

But Kepler's prestige was immense, particularly after Kepler's laws of planetary motion were derived from gravitational theory by Isaac Newton; and so, literary allusions to the two moons of Mars fluttered down the centuries. In Voltaire's longish short story, **Micromegas**, a denizen of the star Sirius noted casually, while touring our solar system, that Mars had two moons. There is a more famous reference to two Martian moons in Jonathan Swift's satire of 1726, **Gulliver's Travels** — not the part about the very small people, or the part about the very large people, or the part about the intelligent horses, but a less widely read part — the part about the floating aerial island of Laputa. The episode is undoubtedly a tightly reasoned critique of English-Spanish relations in Swift's time, because La Puta is Spanish for prostitute. The political metaphors are obscure, at least to me. At any rate, Swift announces casually that astronomers on Laputa have discovered two swiftly moving moons of Mars, and have provided information on their distances from Mars and their periods of revolution about Mars — information which is incorrect, but which is not a bad guess. There is an entire genre of writing on how it was that Swift knew about the moons of Mars, including the suggestion that he was a Martian. Internal evidence suggests that Swift was no Martian, and the two moons can almost certainly be traced directly back to Kepler's speculations.

The actual discovery of the moons of Mars was made from outside Washington, D.C. in 1877. The United States Naval Observatory had just completed a large refracting telescope. The observatory's astronomer, Asaph Hall, sought to learn whether the moons of Mars, fabled in song and story, actually existed. His first few nights were unsuccessful and, in a despondent mood, he announced to his wife his intention of quitting the search. Mrs. Hall would have none of this, and urged her reluctant husband back to a few more nights at the telescope — from whence he emerged with two Martian satellites in hand. For a brief period he thought he had found three satellites, because the inner one moved so rapidly that on one night he saw it on one side of Mars and on the next night on the other. Hall named the moons Phobos and Deimos, after the horses which pulled the chariot of the God of War in Greek mythology; they have the cheerful denotations of fear and terror, respectively. (The appropriate adjectives pose some problems: do we talk of Phobic orbits and Demonic nights?) If another moon of Mars is someday found, I hope we will give it a less ferocious and more optimistic name — like "Pax".

I also hope that when the features on Phobos and Deimos are eventually named by the International Astronomical Union, one will be named after Mrs. Hall. But since another feature will surely be named after Asaph Hall, we have a problem — two craters named Hall would be confusing. In an astronomy talk I gave at Harvard University I commented wistfully that the problem would be solved if only we knew Mrs. Hall's maiden name. My friend, Owen Gingerich, Professor of the History of Science at Harvard, instantly leapt to his feet with the words "Angelina Stickney" trippling off his lips. So when the time comes, I hope there will be a "Stickney" on one of the moons of Barsoom.

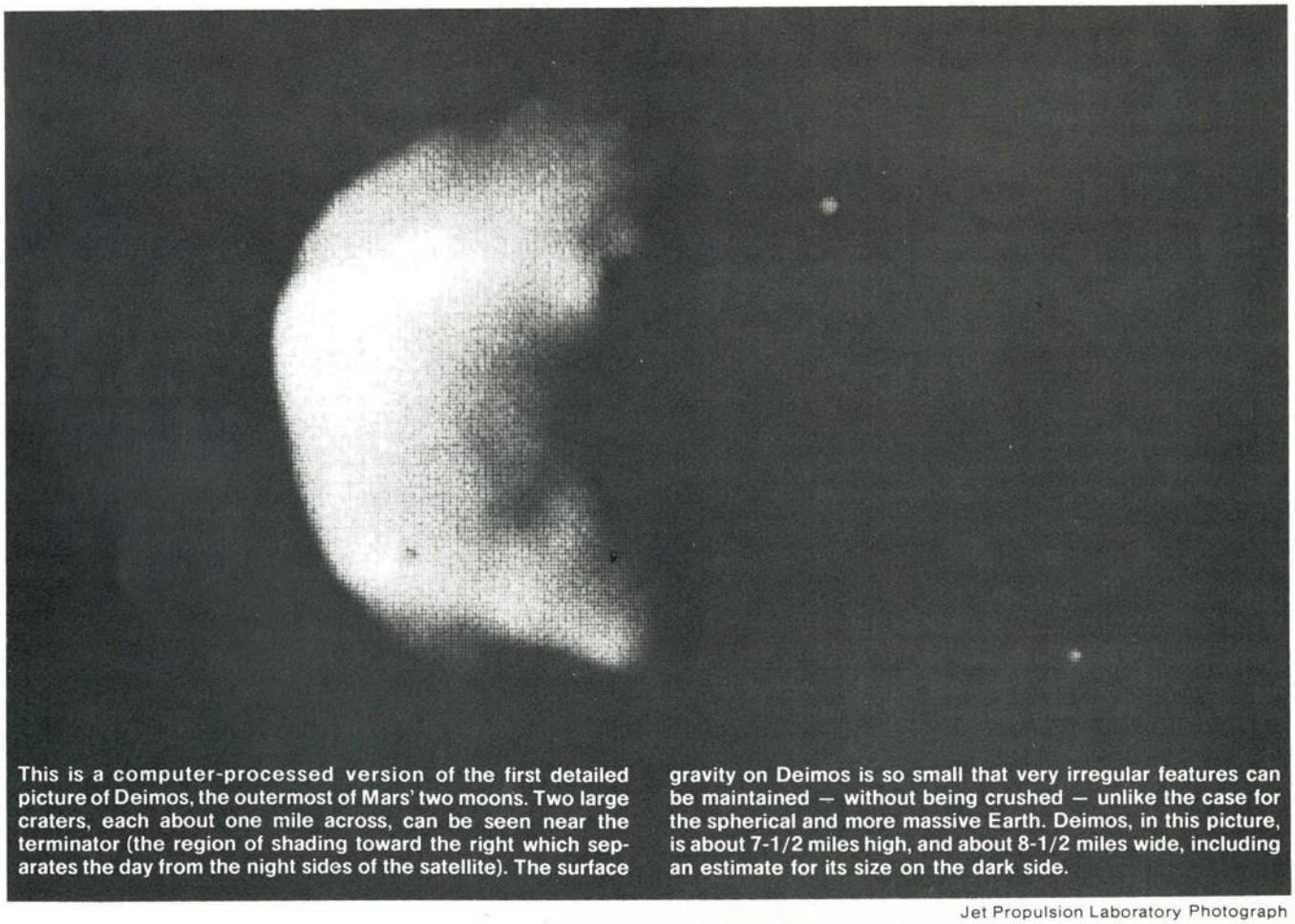
The subsequent study of Phobos and Deimos between 1877 and 1971 has a curious history. The moons of Mars are so tiny that they appear, even to the largest Earth-bound telescopes, as dim points of light. They are too faint for the pre-1877 telescopes to have seen them at all. Their orbits can be calculated by noting their positions at various times. In 1944 at the U.S. Naval Observatory (where an understandable proprietary interest in Phobos and Deimos must have developed), B.P. Sharpless collected all the observations until his time to determine the orbits to the best possible precision. He found — no doubt to his surprise — that the orbit of Phobos appeared to be decaying, what astronomers call a secular acceleration. Over longish periods of time the satellite seemed to be approaching more and more

closely to Mars and moving more and more rapidly. This phenomenon is quite familiar to us today. The orbits of artificial satellites are decaying all the time in Earth's atmosphere. They are initially slowed by collisions with the diffuse upper atmosphere of Earth, but by Kepler's laws the net result is a more rapid motion.

Sharpless' conclusion of a secular acceleration for Phobos remained an unexplained and almost unexamined curiosity until it was considered around 1960 by Soviet astrophysicist I.S. Shklovskii. Shklovskii considered a wide range of alternative hypotheses for the secular acceleration, among them the influence of the sun, the influence of a hypothetical magnetic field on Mars and the tidal influence of the gravity of Mars. He found that none of these came close to working. He then reconsidered the possibility of atmospheric drag. The exact size of the Martian satellites was known poorly and indirectly in those days before spacecraft investigation of Mars, but it was known that Phobos was roughly 10 miles in diameter. The altitude of Phobos above the surface of Mars was also known. Shklovskii and others before him found that the density of the atmosphere was far too low to produce the drag which Sharpless has deduced. It was at this point that Shklovskii made a brilliant and daring guess.

All the calculations showing atmospheric drag to be ineffectual had assumed that Phobos was an object of ordinary density. But what if its density was very low? Despite its enormous size, its mass would then be quite small, and its orbit could be appropriately affected by the thin upper atmosphere of Mars.

Shklovskii calculated the required density of Phobos, and found a value about 1/1000 the density of water. There is no natural object or substance with such low density; balsa wood, for example, has a density of about half the density of water. With such a low density, there was only one conclusion possible: Phobos had to be hollow. A vast hollow object 10 miles across could not have arisen by natural processes. Shklovskii therefore concluded that it was produced by an advanced Martian civilization. Indeed, an artificial satellite 10 miles across requires a technology far in advance of our own; it would also be far in ad-



This is a computer-processed version of the first detailed picture of Deimos, the outermost of Mars' two moons. Two large craters, each about one mile across, can be seen near the terminator (the region of shading toward the right which separates the day from the night sides of the satellite). The surface gravity on Deimos is so small that very irregular features can be maintained — without being crushed — unlike the case for the spherical and more massive Earth. Deimos, in this picture, is about 7-1/2 miles high, and about 8-1/2 miles wide, including an estimate for its size on the dark side.

Jet Propulsion Laboratory Photograph

vance of the technology imagined on Barsoom by Burroughs, which was a kind of sword and small spaceship technology.

Since there were no signs of such an advanced civilization on Mars, Shklovskii concluded that Phobos — and possibly Deimos — had been launched in the distant past by a now extinct Martian civilization. Subsequent to Shklovskii's first work on the subject, the motions of the moons of Mars were re-examined in England by G.A. Wilkins, who found that possibly there was no secular acceleration. But he could not be sure.

Shklovskii's extraordinary suggestion that the moons of Mars might be artificial is one of three hypotheses on their origin. The other two — certainly interesting in their own right, but naturally paling in comparison with the Shklovskii hypothesis — are (1) that the moons are captured asteroids, or (2) that they are debris left over from the origin of Mars itself.

Asteroids are hunks of rock and metal which go around the sun between the orbits of Mars and Jupiter. There are unlikely, but theoretically possible, scenarios in which the gravitation of Mars can capture a close passing asteroid.

In the Martian debris hypothesis, it is imagined that pieces of rock of various sizes fell together to form Mars; that the last generation of such infalling pieces produced the large old impact craters on Mars and that Phobos and Deimos are by chance the only remnants still extant of the early catastrophic history of Mars.

It is clear that establishing any one of these three hypotheses on the origin of the moons of Mars would be a major scientific achievement.

The Mariner Mars mission of 1971, which I had the pleasure to work on was originally to have involved two spacecraft, Mariner 8 and Mariner 9. They were to be placed in different orbits for different purposes in the study of Mars itself. After these orbits were finally agreed upon, I noticed that they were not all that far from the orbits of Phobos and Deimos. It also seemed to me that television and other close-up observations of Phobos and Deimos by the Mariner spacecraft might permit us to determine something of their origin and nature.

Therefore I approached officials of the National Aeronautics and Space Administration, which organized and ran the mission, for permission to program observations of Phobos and Deimos. While the mission controllers at Jet Propulsion Laboratory, the actual operating organization, were not unsympathetic to this idea, some officials at NASA headquarters were against it. There was a mission plan, written in a large book, which stated what Mariners 8 and 9 were about. Nowhere in the mission plan were Phobos and Deimos mentioned. Ergo, I could not look at Phobos and Deimos.

I pointed out that my proposal required only moving the scan platforms on the spacecraft so that the cameras could observe the Martian satellites. The response was negative again. A short time later, I advanced the argument that if Phobos and Deimos were indeed captured asteroids, examining them from Mariner 9 was the equivalent of a free mission to the asteroid belt — the proposed scan platform manuever would save NASA 200 million dollars or so. This argument was judged, at least in some circles, to be more compelling. After about a year's lobbying by me, a discipline group on satellite astronomy was set up and tentative plans were made for examining Phobos and Deimos. The satellite astronomy working group was, at my suggestion, chaired by Dr. James Pollack, a former student of mine; but it was a sign of NASA reluctance that the group was formed only after the launch of Mariner 9, and only about two months before its arrival at Mars. (Mariner 8 had, meanwhile, failed.)

When Mariner 9 arrived at Mars, we found a planet almost entirely obscured by dust. Since there was little to look at on Mars, a great and previously undetectable enthusiasm for examining Phobos and Deimos dramatically materialized. The first step was to take wide-angle photographs from a distance in order to establish with some precision the orbits and locations of the moons. This task was accomplished in a preliminary way about two weeks after injection of the spacecraft into Martian orbit. Mariner 9 has an orbital period of about 12 hours, so that it made close to two revolutions about Mars per day.

The television pictures from Mariner 9 were radioed from Mars to Earth in much the same way that a newsprint wirephoto is transmitted on Earth. The picture is divided into a larger number of small dots (for Mariner 9, several hundred thousand dots), each dot with its own brightness, or shade of gray, running from black to white. After the picture is taken by the spacecraft, and recorded there on magnetic tape, it is played back to Earth, dot by dot. The communication says, in

The volcanic shield of Nix Olympica (right) looms six miles above the Martian plains into the thin atmosphere in this early morning view. Thin clouds form lee wave patterns from the summit caldera. Between the clouds can be seen the irregular shape of Mars' inner moon, Phobos, while Deimos, at 12,500 miles distant, appears as a bright star.

Original painting for ASTRONOMY by Victor Costanzo

effect: dot number 3277, gray level 65; dot number 3278, gray level 62, and so on. The picture is reassembled by computer on Earth — essentially by following the dots.

On revolution 34, Mariner 9 and Phobos came less than 4,000 miles of each other, one of the closest approaches in the entire mission. (See photograph on page 11.) I am not sure what an artificial satellite 10 miles across looks like, but this does not seem to be it. Phobos looks not so much like an artificial satellite as a diseased potato. It is, in fact, very heavily cratered. For it to have accumulated so many craters in that part of the solar system, it must be very old, probably billions of years old.

Phobos appears to be an entirely natural fragment of a larger rock severely battered by repeated collisions; holes have been dug, pieces have been chipped off. It looks a little like the hand axes, chipped along natural fracture planes, made by our Pleistocene ancestors. There is no sign of technology on it. Phobos is not an artificial satellite. When pictures of Deimos were computer contrast-enhanced, the same conclusions applied to it. (See photograph on page 7.)

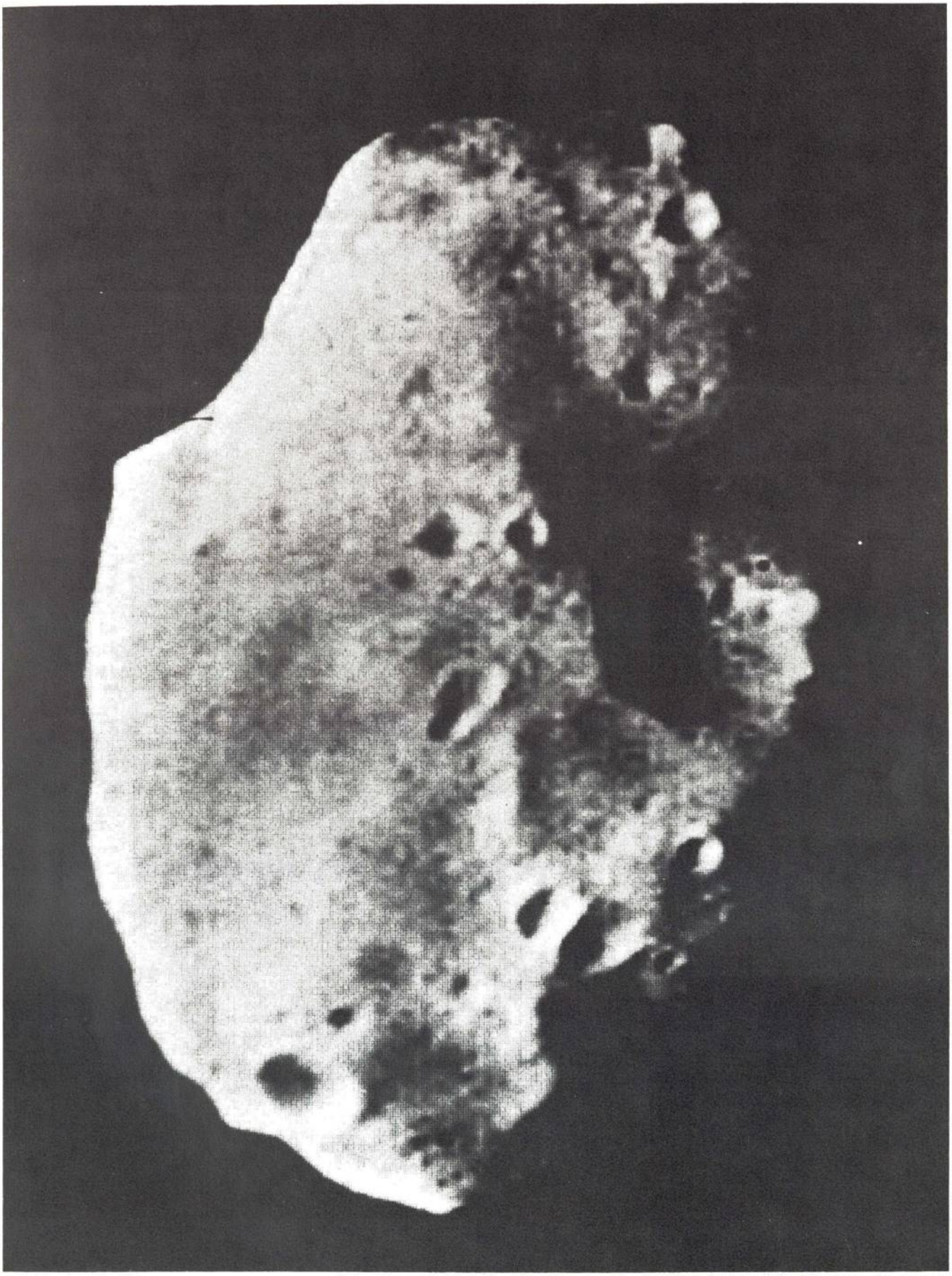
Phobos and Deimos are the first satellites of another planet to have been photographed close-up. They were also observed by the ultraviolet spectrometer and the infrared radiometer on board Mariner 9. We have been able to determine their sizes and shapes and something of their color. They are extremely dark objects — darker than the darkest material that is likely to be in the room in which you are sitting right now. Indeed, they are among the very darkest objects in the solar system. Since there are so few objects this dark anywhere, we hope to be able to conclude something about their composition. They are both covered by at least thin layers of finely pulverized material. They provide important clues to collisional processes in the early solar system. I believe we are looking at the end-product of a kind of collisional natural selection, in which fragments have been broken off from a larger parent body, and we are seeing only the two pieces, Phobos and Deimos, which remain. The moons of Mars are also important collision calibrators for Mars. Phobos, Deimos and Mars have very likely been together in the same part of the solar system for a very long period of time. The number of craters of a given size on Mars is much less, in general, than on Phobos and Deimos, providing important information on erosional processes which exist on Mars and which do not exist on airless and waterless Phobos and Deimos.

Because we now have the first good information on the size and shape of these objects, and because we now have good reason to think that they have typical densities of ordinary rock, we can calculate something about what it would be like to stand on, let's say, Phobos. First of all, Mars, less than 6,000 miles away, would fill about half the sky of Phobos. Mars rise would be a spectacular event. Eventual construction of an observatory on Phobos to examine Mars might not be such a bad idea. We know from Mariner 9 that both Phobos and Deimos are rotating as our moon does, always keeping the same face to their planet. When Phobos is above the day hemisphere of Mars, the reddish light of Mars would be easily enough to read by at night on Phobos.

Because of their small sizes, Phobos and Deimos have very low gravitational accelerations. Their gravities do not pull very hard. The pull on Phobos is only about 1/1000 that on Earth. If you can perform a standing high jump of two or three feet on Earth, you could perform a standing high jump of half a mile on Phobos. It would not take many such jumps to circumnavigate Phobos. They would be graceful, slow, arcing leaps, taking many minutes to reach the high point of the self-propelled trajectory and then to return gently to the ground.

Even more interesting would be a game like baseball on Phobos. The velocity necessary to launch an object into orbit about Phobos is only about 20 miles per hour. An amateur baseball pitcher could easily launch a baseball into orbit around Phobos. The escape velocity from Phobos is only about 30 miles per hour, a speed easily reached by professional baseball pitchers. A baseball which had escaped from Phobos would still be in orbit about Mars — a man-launched moonlet. If Phobos were perfectly spherical, a lonely astronaut with an interest in baseball could invent a curious but somewhat sluggish version of this already rather sluggish game. First, as pitcher, he could throw the ball sidearm at the horizon. He could then go home for lunch, because it will take about two hours for the baseball to circumnavigate Phobos. After lunch, he can pick up a bat, face the other direction and await his pitch of

The most detailed image of Phobos available to date is seen in this computer-enhanced photograph (right) taken by Mariner 9 during its 34th orbit of Mars. Distance from the spacecraft camera to the Mars moon was about 3,400 miles. The large crater at right center appears to have at least one small crater on its rim. More than a dozen other small craters are visible. The profusion of these craters suggests that Mars' innermost moon is very old and possesses considerable structural strength. The irregular edge at top left may have been produced when an asteroid impacted the larger parent body of Phobos.

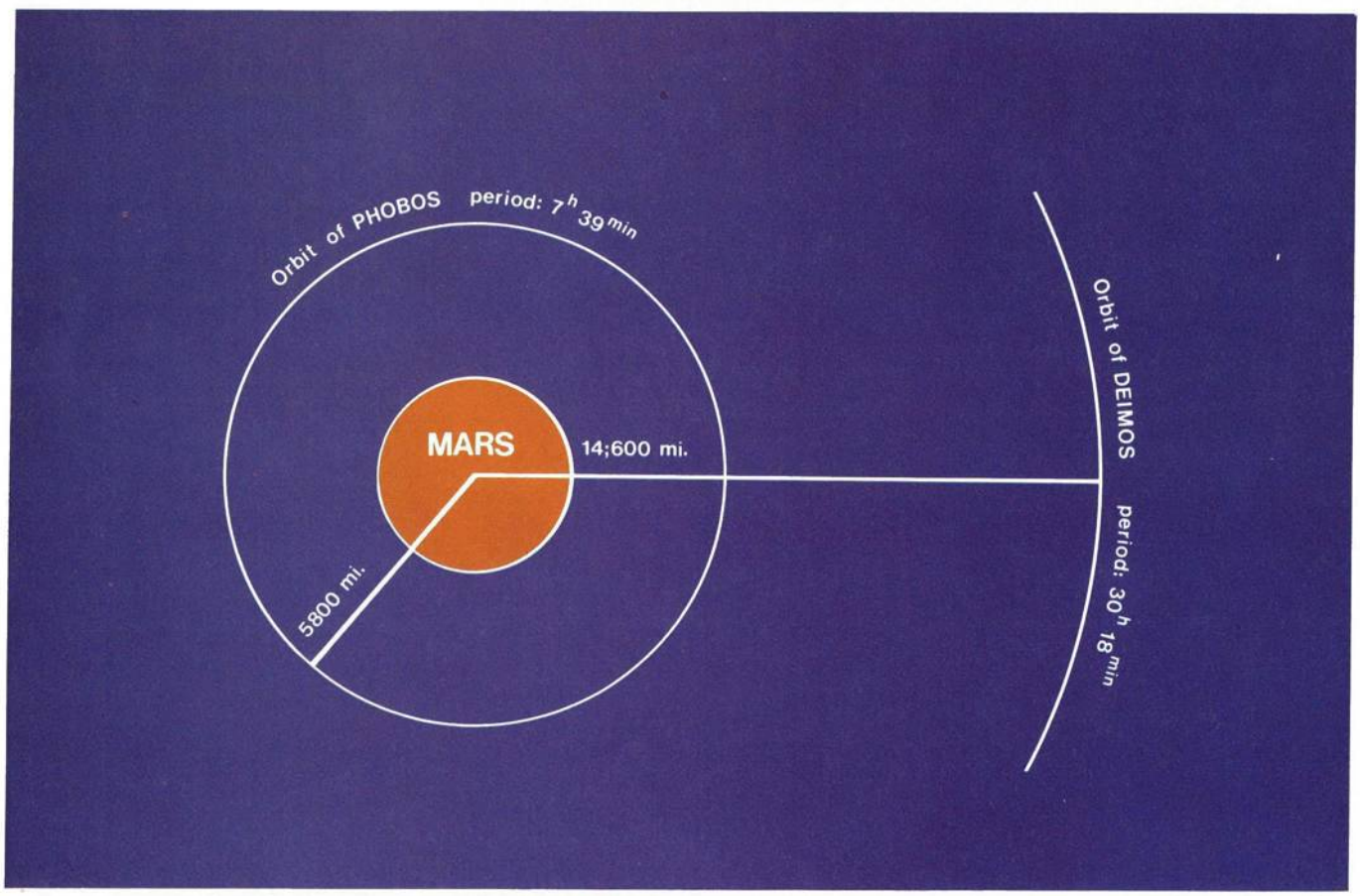


Jet Propulsion Laboratory Photograph

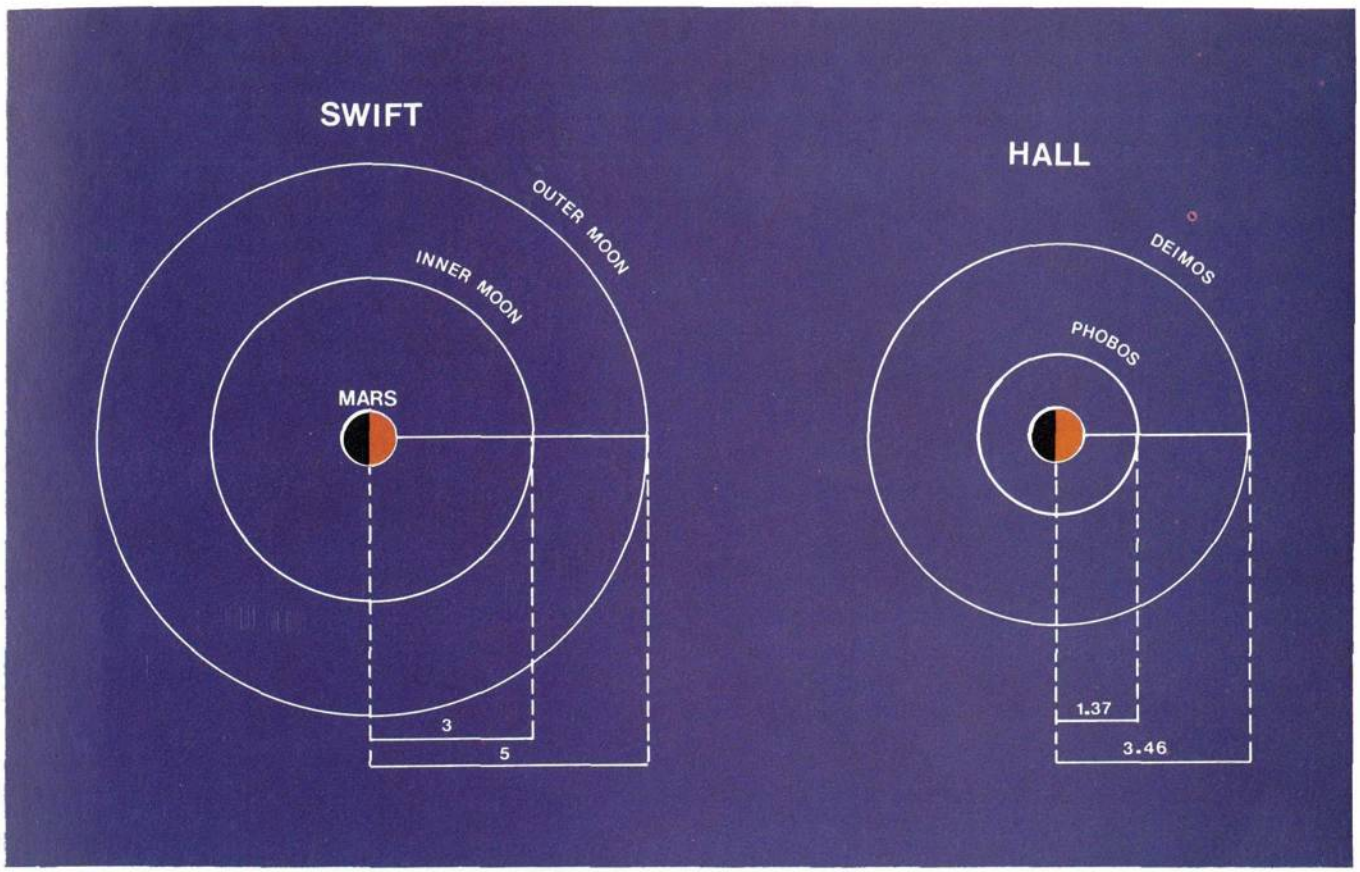
two hours earlier. Apart from the fact that good pitchers are seldom good hitters, hitting this pitch would be pretty easy: about 15 seconds elapse from the appearance of the baseball at the horizon to its arrival in the vicinity of our astronaut. If he swings and misses — or, more likely, if the ball is wide of the plate — he can then go home for a two hour nap, returning with his catcher's mitt to catch the ball. Alternatively, if he succeeds in hitting a fly ball at a velocity somewhere between 20 and 30 miles per hour, he can go home and take his nap, returning this time with a fielder's mitt, awaiting the return of the ball from the opposite horizon two hours later. Because Phobos is gravitationally lumpy, the game would be more difficult than I have indicated. Since daylight on Phobos lasts only about four hours, lights would have to be erected, or the game modified so that all pitching, hitting, and catching events happen on the day side.

These sports possibilities may one day, a century or two hence, provide a tourist industry for Phobos and Deimos. But baseball on Phobos is no more an argument for going there than, to take a random example, golf is for going to the moon. The scientific interest in the moons of Mars — whether captured asteroids or debris from the formation of the planet — is immense. Sooner or later, certainly on a time scale of centuries, there will be instruments — and then men — on the surface of Phobos looking up with awe at an immense red planet which fills the sky, zenith to horizon.

And what about the opposite view? What do the moons of Barsoom look like from the surface of Mars? Because Phobos is so close to Mars, it would be seen as a clearly discernible disk, even though it is intrinsically such a tiny object. In fact, Phobos would appear as about half the apparent size of our moon seen from the surface of Earth. We have found from Mariner 9 that only one side of Phobos is visible from Mars, just as only one side of our moon is visible from Earth. That face of Phobos is, more or less, the face in the photograph on page 11. Until Mariner 9, no



The distance of Phobos and Deimos from Mars' center is illustrated above. Both the planet and the orbits of the moons are drawn to scale. The moons themselves are too small to show on this scale.



Jonathan Swift, of Gulliver's Travels fame serendipitously "predicted" the existence of Phobos and Diemos. The above illustration demonstrates the astonishing agreement between Swift's guess and Asaph Hall's observations of the satellites' distance from Mars. The distances are given with the diameter of Mars as the measuring unit.

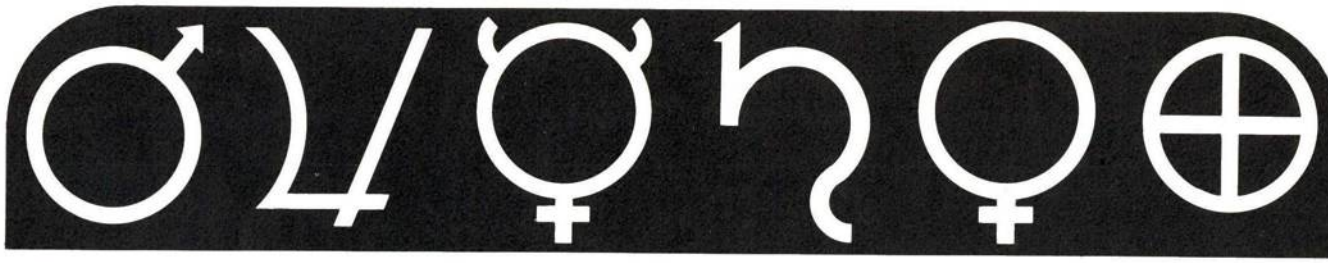
one — except Martians, if such there be — ever knew that face.

Because Phobos is so close to Mars, Kepler's laws constrain it to move comparatively rapidly about the planet. It makes approximately 2-1/2 revolutions about Mars in 24 hours. Deimos, on the other hand, takes 30 hours 18 minutes to revolve in its orbit once about Mars. Both moons revolve in their orbits in the same direction or sense as Mars rotates on its axis. Thus, Deimos rises in the east and sets in the west as — from terrestrial chauvinism — we believe a well-behaved satellite should. But Phobos makes it once around its orbit in less time than it takes for Mars to rotate. Accordingly, Phobos rises in the west and sets in the east, taking about 5-1/2 hours to transit from horizon to horizon. This is not exactly "hurtling" — the motion would not be perceptible against the field of stars in a minute's watching — but it's not plodding, either. There will be some nights at the equator on Mars when Phobos sets in the east at sunset and then rises in the west well before dawn.

Phobos is so close to the plane of Mars that it is entirely invisible from the polar regions of the planet. If we were to imagine intelligent beings developing on Mars, astronomy might very well be the province of only the equatorial, and not the high latitude, societies. I am not sure whether Helium was an equatorial kingdom of Mars.

Freud says somewhere that the only happy men are those whose boyhood dreams are realized. I cannot say that it has made my life carefree. But I will never forget those early morning hours in a chilly California November when Joe Veverka, a JPL technician, and I were the first human beings ever to see the face of Phobos.

The state of California was kind enough to give me an automobile license plate marked "PHOBOS". My car is not particularly sluggish, but it cannot circumnavigate our planet twice a day either. The license plate pleases me. I would have preferred "BARSOOM", but there is a strictly enforced limit of six letters per license plate.



SKY ALMANAC

Parade of Planets Herald D.S.T. Demise at Month's End

by

Terence Dickinson

Mars, at its nearest in two years, Jupiter due south at dusk and Venus dazzling in the west, combine to make this the best month of the decade for backyard planet watchers.

Mars

The red planet is the number one object for any telescope this month. At 10 p.m. E.D.T. on October 16, Mars and Earth will be 40.5 million miles apart — not quite as close as in 1971, but this year is the best bet for amateur observers. (See last month's Gazer's Gazette for complete details on Mars observing.)

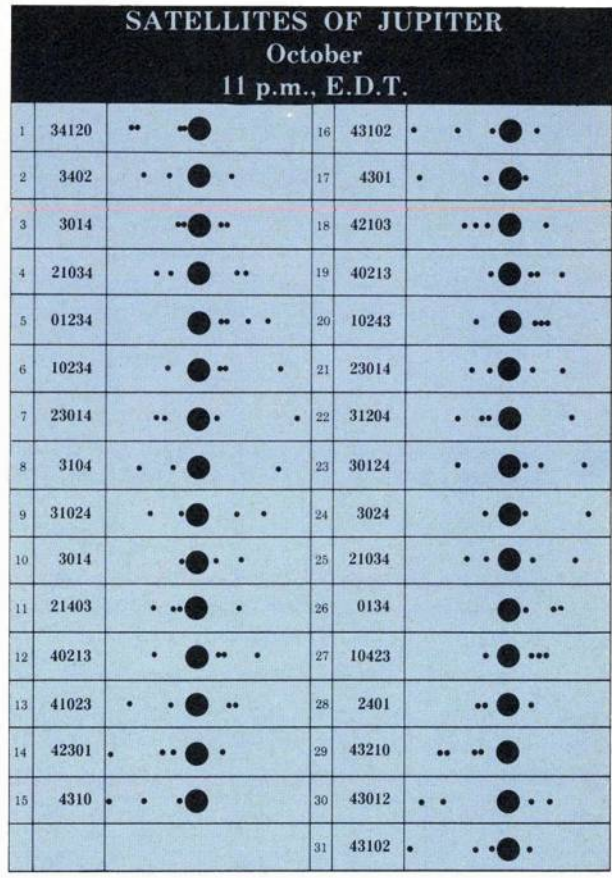
Mars is brilliant at magnitude -2.2, making it brighter than any star or planet except Venus. But Mars seems brighter partly because it is so high in the sky, especially around midnight, and partly because there are no bright stars around it.

As the sky darkens on October evenings the spectacle of bright planets is unparalleled in recent years. Mars, Jupiter and Venus mark the approximate east, south and west points, their characteristic orange, yellow and white hues as distinct as they are brilliant.

October is a fine month for planet watching — or any skygazing for that matter. Sunset is early, about 7 p.m. local daylight time, and backyards are bug-free. Evening temperatures invite sky observing so every opportunity to scan the surface of the most earthlike planet should be seized. Remember — the next best chance will be 1986.

Jupiter

Due south at dusk, the giant planet beckons scrutiny as its steady light overshadows the surrounding stars of the dim zodiac constellation, Capricornus.



The positions of Jupiter's four brightest moons change hourly and daily, and make an interesting sight to view even in a small telescope or high powered binoculars. Shown above is the approximate appearance of Jupiter and its satellites as they might look in a small telescope at 11 p.m., EDT. First column on the left shows the date. Second column of numbers identifies the moons and their position relative to Jupiter's disk. (1 Io; 1 Europa; 3 Ganymede; 4 Callisto, and 0 Jupiter's disk.) The third column approximates a telescopic view of the satellites' positions.

At magnitude -2.0, Jupiter has faded — though not noticeably — since opposition last July. During the month its distance increases from 425 to 469 million miles from Earth. Meanwhile its equatorial diameter diminishes from 43 to 39.1 seconds of arc during the same period.

Observers have reported the Great Red Spot as a prominent pink oval this year, equal to its performance in recent years. However the spot does have periods — sometimes lasting years — when it is dull and seen only in larger telescopes.

In recent issues we have reported the rare phenomenon of one satellite of Jupiter casting its shadow on another satellite. Only two such events occur in October, both on the evening of the 29th. In the first event Ganymede's (3) shadow will partially cover Europa (2) for a few minutes around 8:50 p.m. E.S.T. In the second, the shadow of Callisto (4) will partially block Europa (2) almost two hours later, 10:50 p.m. E.S.T. See if you can notice a fading in Europa's brightness during the eclipses which last several minutes. The exact amount of fading is unpredictable so ASTRONOMY will be interested in our reader's reports on these events.

Below is a table listing shadow transits (satellite shadows on the disk of Jupiter) for observers using three inch and larger telescopes.

Venus

At last our early evening planet is offering an interesting sight in small telescopes. A 60mm scope should be sufficient to see the gibbous shaped planet this month. On the 1st, the 67 percent illuminated disk is 17 seconds of arc in diameter. By month's end the 56 percent, near "half" image will have increased to 22.1 seconds of arc.

The Earth-Venus distance is constantly decreasing as the planet brightens. On October 1 the distance is 93 million miles and on the 31st, 72 million miles. Apparent magnitude increases from -3.7 to -4.0 this month.

Saturn

For late night observers, the ringed planet is well placed in the eastern sky after midnight. At magnitude +0.2, Saturn is about the same brightness as the two major stars in Orion — Betelgeuse (magnitude +0.4 and slightly variable) and Rigel (magnitude +0.1). A line from Rigel to Betelgeuse, if extended an equal distance, will point to Saturn. A major feature on observing Saturn will appear in the December issue.

Mercury

Mercury is too near the sun to be easily seen this month.

Asteroids

None of the brighter asteroids are suitably situated for easy observation in October. For their relative positions in the zodiac, see the planet finder on pages 16 and 17 .

Alberio

When you're tired of planet observing or you want to show someone who has never seen a star what they really look like, turn your scope to Alberio. Any telescope from a two inch refractor

SATELLITE SHADOWS ON JUPITER

Date	Satellite	Transit begins (EDT)	Transit ends (EDT)
Oct. 2-3	1	10:06 p.m.	12:23 a.m.
3	2	9:02 p.m.	11:51 p.m.
10	1	12:01 a.m.	2:19 a.m.
10-11	2	11:38 p.m.	2:27 a.m.
11	1	6:30 p.m.	8:48 p.m.
14	3	6:57 p.m.	10:33 p.m.
18	1	8:26 p.m.	10:44 p.m.
21	3	10:58 p.m.	too near horizon
25-26	1	10:22 p.m.	12:39 a.m.
28	2	6:07 p.m. (EST)	8:56 p.m. (EST)

1 = Io
2 = Europa
3 = Ganymede
4 = Callisto

VESTA

October	1	16
R.A.	10ʰ26ᵐ	10ʰ52ᵐ
DEC.	+13° 17′	+11° 12′
DIST.	3.190 A.U.	3.056 A.U.
MAG.	+7.9	+7.9

THIRD QUARTER
October 18

R.A.	7ʰ49ᵐ
DEC.	+18° 55′

SATURN

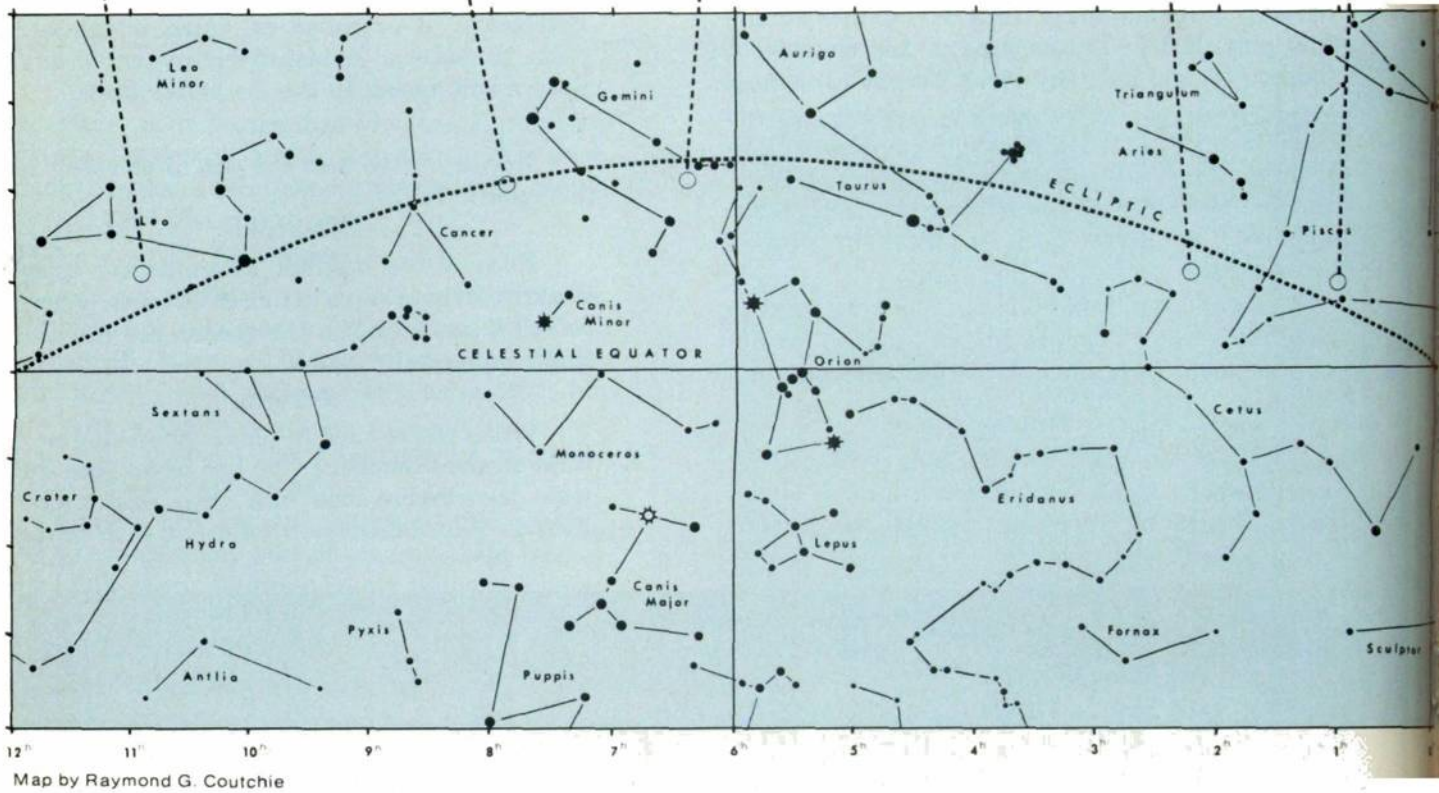
October	1	16
R.A.	6ʰ19ᵐ	6ʰ21ᵐ
DEC.	+22° 17′	+22° 16′
DIST.	8.905 A.U.	8.662 A.U.
DIA.	16.7″	17.2″
MAG.	+0.2	+0.2

MARS

October	1	16
R.A.	2ʰ28ᵐ	2ʰ13ᵐ
DEC.	+11° 24′	+10° 49′
DIST.	0.456 A.U.	0.436 A.U.
DIA.	20.5″	21.4″
MAG.	-1.9	-2.2

FULL MOON
October 12

R.A.	1ʰ01ᵐ
DEC.	+11° 43′



Map by Raymond G. Coutchie

JUPITER

October	1
R.A.	20ʰ19ᵐ
DEC.	-20° 24′
DIST.	4.574 A.U.
DIA.	40″
MAG.	-2.1

This planet finder chart shows the positions of the sun, moon, planets and brighter asteroids for the current month as they appear against the background of the zodiac. Positions are plotted for the 15th with additional ephemerides for the 1st. To find zodiacal constellations visible during the current month, see Star Dome.

JUNO

October	1	16
R.A.	16 59	17 15
DEC.	-10 50	-11 56
DIST.	3.393 A.U.	3.554 A.U.
MAG.	+10.8	+10.8

PALLAS

October	1	16
R.A.	15 51	16 10
DEC.	+9 21	+7 31
DIST.	3.579 A.U.	3.722 A.U.
MAG.	+9.8	+9.8

SUN

October	1	16
R.A.	12 28	13 23
DEC.	-3 03	-8 45
DIST.	1.001 A.U.	0.996 A
DIA.	32	32

FIRST QUARTER

October 4

R.A.	18 49
DEC.	-22 11

NEW MOON

October 26

R.A.	13 55
DEC.	-16 21

PLUTO

October	1	16
R.A.	12 41	12 43
DEC.	+13 04	+12 52
DIST.	31.970 A.U.	31.909 A
MAG.	+14	+14

CERES

October	1	16
R.A.	16 58	17 18
DEC.	-25 10	-25 55
DIST.	3.087 A.U.	3.279 A.U.
MAG.	+8.3	+8.3

NEPTUNE

October	1	16
R.A.	16 14	16 16
DEC.	-19 37	-19 42
DIST.	30.835 A.U.	31.029 A.U.
DIA.	2.36	2.36
MAG.	+7.7	+7.7

MERCURY

October	1	16
R.A.	13 40	14 54
DEC.	-11 36	-19 27
DIST.	1.264 A.U.	1.060 A.U.
DIA.	7.9	6.3
MAG.	-0.1	+0.1

NEW MOON

September 26

R.A.	12 04
DEC.	-5 56

16
20 21
-20 17
4.794 A.U.
38.3
-2.0

VENUS

October	1	16
R.A.	15 10	16 21
DEC.	-19 31	-24 07
DIST.	0.993 A.U.	0.882 A.U.
DIA.	16.9	19.0
MAG.	-3.7	-3.8

URANUS

October	1	16
R.A.	13 24	13 27
DEC.	-8 12	-8 33
DIST.	19.380 A.U.	19.411 A.U.
DIA.	3.5	3.5
MAG.	+5.7	+5.7

up will clearly resolve this most beautiful of all double stars.

Alberio is the common name for Beta Cygni — the star at the foot of the "Northern Cross" (see Star Dome). Use your lowest power eyepiece to examine the striking color difference between the two stars. The brighter is yellow and magnitude 3.1. The fainter of the pair is a beautiful blue, magnitude 5.1. Separation is 34 seconds of arc — a little less than the apparent width of Jupiter.

Actually the two stars are giants. The yellow one is 760 times as luminous as the sun and the fainter is 120 times as brilliant as Sol. The actual distance separating the stars is over 400 billion miles — more than 100 times Pluto's distance from the sun. Alberio is 410 light-years from us.

DAYLIGHT SAVING TIME ENDS OCTOBER 28

Observers aggravated last spring by the arbitrary addition of one hour of light to the dusk end of their observing evening may breathe a sigh of relief as Daylight Saving Time meets its long awaited end on Sunday morning, October 28. At 2:00 a.m. Sunday (that's on the night side of Saturday), in all time zones across the United States, clock and watch hands should be flipped backward to read 1:00 a.m.

Then, Sunday evening when you begin your evening's observing, won't it be great to see the sky the way it should be at 8:00 p.m.?

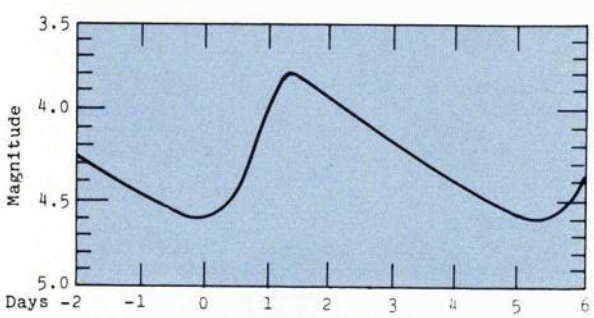
OCTOBER VARIABLE STAR

Delta Cephei

by

R. Newton Mayall

In 1784, John Goodricke of York, England, a deaf mute and an avid variable star observer, was the first to notice that Delta Cephei varied in light intensity.



The above light curve shows the 5.37 day period of variable star Delta Cephei. The star is a naked eye variable whose magnitude range is between 3.8 and 4.6.

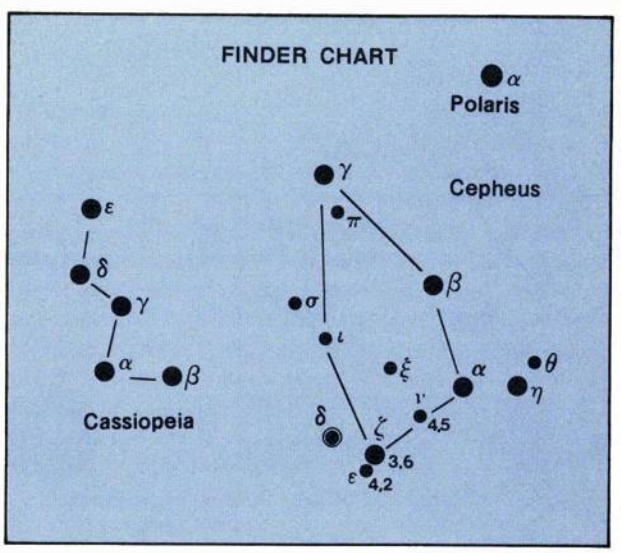
Delta Cephei is an excellent variable star for the beginner to observe, because it is visible to the naked eye throughout its period. No optical aid is required. It ranges in magnitude from 3.8 to 4.6 in a period of 5.37 days. Its fluctuations are quite uniform and show a sharp rise to maximum and a slower decline to minimum. This is the characteristic of a large group of stars known as the Cepheids, Delta being the prototype, which gives them their name. Because it continually varies in the same pattern, Delta Cephei is frequently used as a classroom exercise.

Cepheids are referred to as the yardsticks of our universe. Their special characteristics enable us to measure the distance of many spiral nebulae and clusters in which they appear.

The term Cepheid is applied to these variables having regular periods of 1 to 75 days, whose light curves are like those of the prototype Delta Cephei (see light curve illustration). They are quite steady in period and in form of light curve. The maximum is generally more sharply defined than the minimum.

The accompanying chart locates Delta Cephei and it is indicated by a dot within a circle. It is at the apex of a small isosceles triangle formed by the stars Delta, Epsilon, and Zeta. The comparison stars are indicated by the magnitudes 3.6, 4.2, and 4.5.

With this information you can make your own light curve of this interesting star's variation.



Using the above chart an observer can easily locate the variable star Delta Cephei. To locate the constellation Cepheus in the October sky, refer to Star Dome. Without a telescope, and using the magnitude comparison stars surrounding Delta, an observer will be able to easily construct a light curve similar to the one accompanying this article.

easily locate any celestial object

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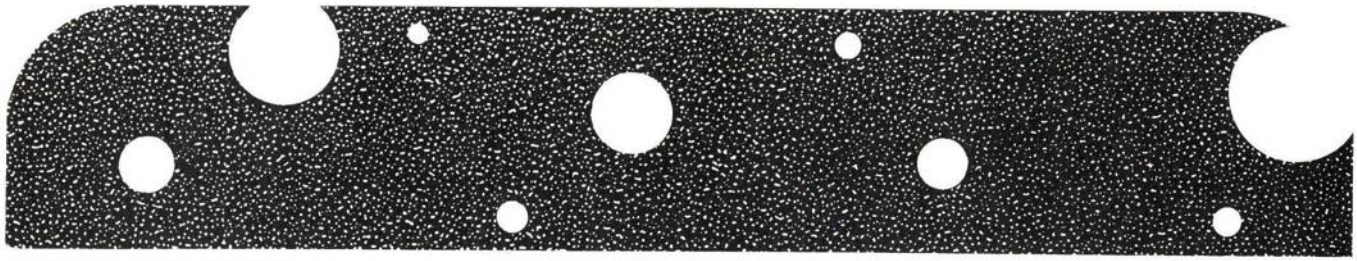


Hercules X-1: How to Weigh a Pulsar

by

Wm. Bruce Weaver

Neutron stars were predicted as theoretically possible in the 1930s. In 1968 astronomers discovered pulsars and these objects are now generally accepted as rapidly rotating neutron stars. Finally, four decades after they were predicted, astronomers have been blessed with their first opportunity to determine a neutron star's mass.

The star is Hercules X-1, an x-ray emitting object in the constellation Hercules. It was discovered by scientists from observations with a satellite equipped to detect x-rays from cosmic sources. Not only is this object a pulsar, but it now appears that it is the companion of the long known peculiar variable star HZ Herculis. This neutron star's physical association with an optical star permits astronomers to estimate its mass.

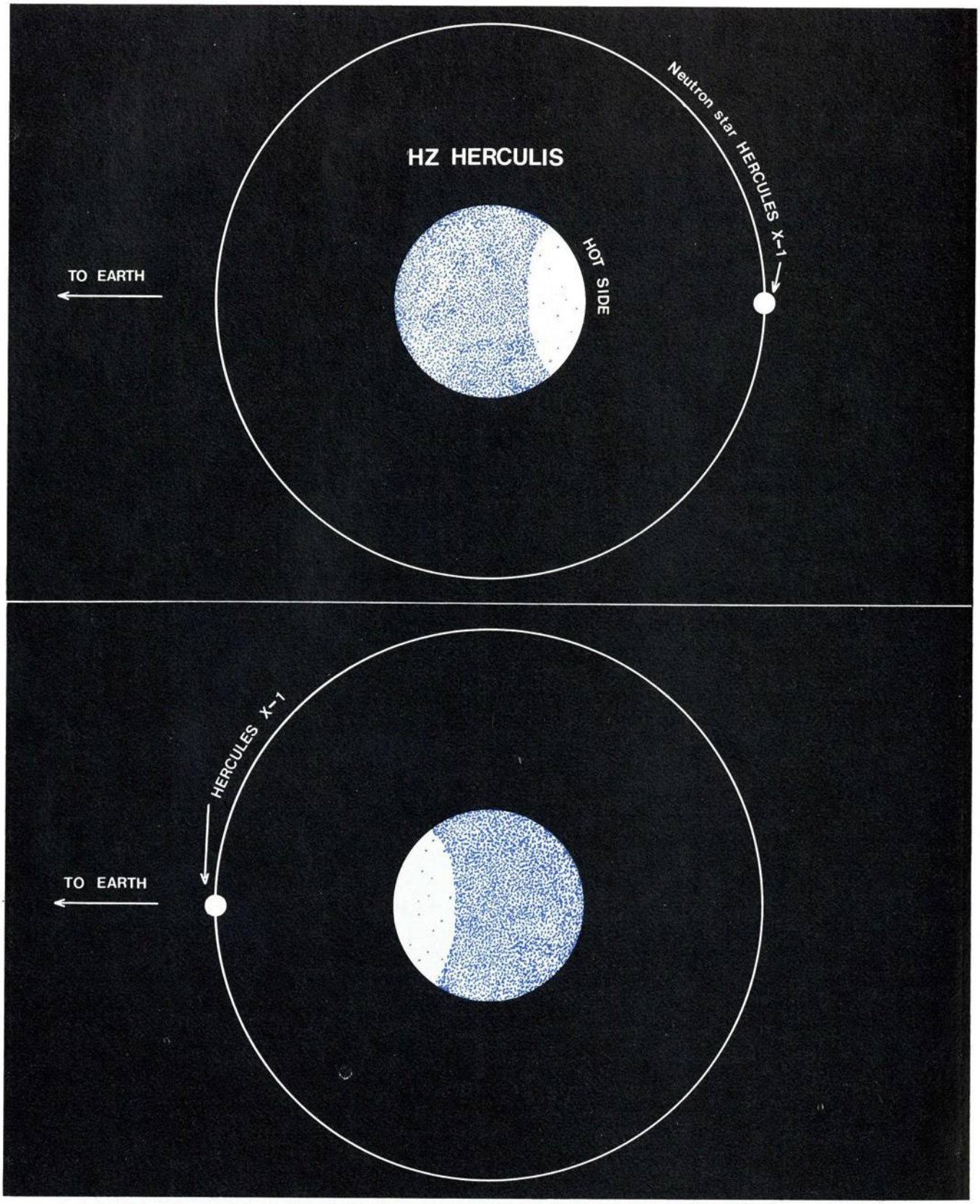
Although neutron stars were predicted in the 1930s, not enough was known about stellar evolution to predict how neutron stars were formed. By the late 1950s astronomers had sophisticated their theories on the evolution of stars and were able to suggest that a neutron star might be the collapsed remains of a massive star after it had gone supernova. (The supernova stage in a star's evolution probably takes place late in its life. Essentially, the star explodes violently, blowing most of its matter into inter-stellar space, causing it to become very bright for a few weeks or months.) Neutron stars, astronomers reasoned, would be so faint that they might never be observed from Earth and would remain as only "possible" members of the universe.

In 1968, however, radio astronomers at the University of Cambridge announced they had discovered a strange class of distant objects which emitted accurately timed bursts of radiation. These objects were soon named pulsars. Radio pulses from these new objects had periods ranging from 1/4 to 1.3 seconds — and their periods had incredibly accurate repeatability. What kind of object could have such short periods and yet have such exact repeatability? Someone even suggested that they might be cosmic beacons that serve to guide "little green men" on their interstellar voyages. Astronomers analyzed the shapes and periods of the radio beats, eliminating every other possible source except rapidly rotating neutron stars.

What is a neutron star? If ordinary atoms are extremely compressed, electrons are forced into the protons of the nuclei, converting them into neutrons. At high enough densities, the repulsive forces of neutrons acting on each other finally keep the star from collapsing any further. When this stage is reached, the average density of a neutron star is something like a billion tons per cubic inch! Gravitational force is so great that ordinary physics is inadequate to describe what happens in neutron stars. A reasonably full explanation must include corrections due to general relativity. These objects have small diameters on the order of about

The Crab Nebula in the constellation Taurus (right) is thought to be the gaseous remains of a star which suffered a supernova explosion in 1054 A.D. There is a pulsar located near the center of the nebula, with a period of about 1/30 second.

Photograph copyright by the California Institude of Technology and the Carnegie Institution of Washington.



In the illustration above, x-rays from Hercules X-1 are blocked from Earth by HZ Herculis. Also, the hot side of HZ Herculis — the side constantly bombarded by x-rays from the neutron star — faces away from us, so both x-ray and optical intensities are at a minimum as viewed from Earth. Half a period later (about 20 hours) the x-ray pulsar and the hot side of the optical star have rotated to face Earth. As seen from Earth, x-ray intensity and light intensity appear at maximum.

10 miles, and they weigh as much as the sun. Nevertheless, they can complete a rotation in about one second. Hence, the mechanisms invoked to explain the periodicity of the radio pulses usually center around the rotation of the neutron star. Even though most pulsars are observed with radio telescopes, optical and x-ray pulsar radiation has also been observed.

Until the discovery of Hercules X-1, there had been no opportunity to measure a neutron star's mass. Masses used in calculations and discussions were only theoretically predicted but never verified by observing a real neutron star.

Hercules X-1 has a pulsar period of 1.24 seconds. This, astronomers assume, is the rotation period of the neutron star. Every 1.7 days these regular pulsations are interrupted. Astronomers believe this is caused by the companion star passing in front of the pulsar, and blocking away the x-rays. To further confuse matters, there is also a 35 day modulation when the x-rays seem to be turned off for about 25 days out of every 35.

At first, the position of the x-ray source was not accurately known because of limitations in the satellites' ability to pinpoint the source as it spins around. There were many stars in the area that could have been associated with the x-ray source. However, William Liller of Harvard University suggested that the variable star HZ Herculis might be involved. This peculiar blue variable is located in the same general area as the x-ray source. John and Neta Bahcall, a husband and wife team associated with the Institute for advanced Study and Princeton University respectively, examined the light variations of HZ Herculis' period. They found that maximum brightness occurred every 1.7 days! Not only is the period of the optical star the same as the x-ray source but the minimum of the x-ray emission coincides with the minimum of the light from the variable star.

Attempts to detect optical pulsations in HZ Herculis have yielded mixed results. Some observers have reported faint pulsations while other astronomers have not been able to find any.

The Bahcalls suggest that the neutron star and the optical star are in orbit around each other. If one side of the optical star always faces the pulsar (as one side of the moon always faces Earth), it would become hotter than the rest of the star because it is continually being bombarded with x-rays.

When the x-ray star is behind HZ Herculis, the optical star (as illustrated on page 22), not only are the x-rays blocked from the view of the earth, but the hotter side of HZ Herculis is also facing away from us. As a result, both the optical and x-ray minima occur at the same time. The time of both the x-ray and optical light maxima is also shown in the illustration. Here the pulsar is on the side facing Earth, so now we can observe the x-rays. At the same time, the hot side of the optical star is also facing the earth and we observe a maximum in the light intensity.

Several methods have been employed to determine the mass of the neutron star in the HZ Herculis system. First, the light from HZ Herculis is examined when the unheated side is facing the earth. From this a mass for the star can be determined. By observing details of the x-ray pulses, the mass of the neutron star can be related to the mass of the optical star. This provides a value for the neutron star's mass of about 50 to 60 percent the mass of the sun.

Another method of determining the star's mass is to examine the orbit of the optical star. By observing HZ Herculis' velocity in its orbit, the mass of the neutron star can be determined. This method gives a value between 30 and 80 percent the mass of the sun. Other techniques yield masses ranging as high as 1.3 times the mass of the sun.

More careful measurements in the next year will improve estimates of the neutron star's mass. The range of masses determined so far is within the range of what was theoretically predicted for neutron stars. Theoreticians claim that a neutron star cannot have a mass greater than about three times the mass of the sun. This prediction, of course, encourages everyone to look for other, more massive neutron stars.

Have all the observed features of Hercules X-1 been explained now? No. The 1.24 second period of the x-ray pulses is thought to be due to the rotation of the neutron star. The 1.7 day period is thought to be the time needed for the optical star and the neutron star to make a complete orbit about each other. Why the x-ray source is turned off for 25 days out of every 35 is not yet explained. The variability of HZ Herculis does not provide a clue. Examination of old observations of HZ Herculis shows that sometimes it stays at minimum light for months or even years. This seems to indicate that the x-ray pulses may turn off for long periods of time.

There is no doubt that the first attempts to explain the behavior of Hercules X-1 and HZ Herculis have been very fruitful, but many interesting problems still remain. It has been a long time since neutron stars were first predicted, but now it seems with the help of x-ray detecting satellites astronomers have finally weighed one.

OCTOBER

Stars in each constellation are indicated, in order of brightness, with the Greek Alphabet.

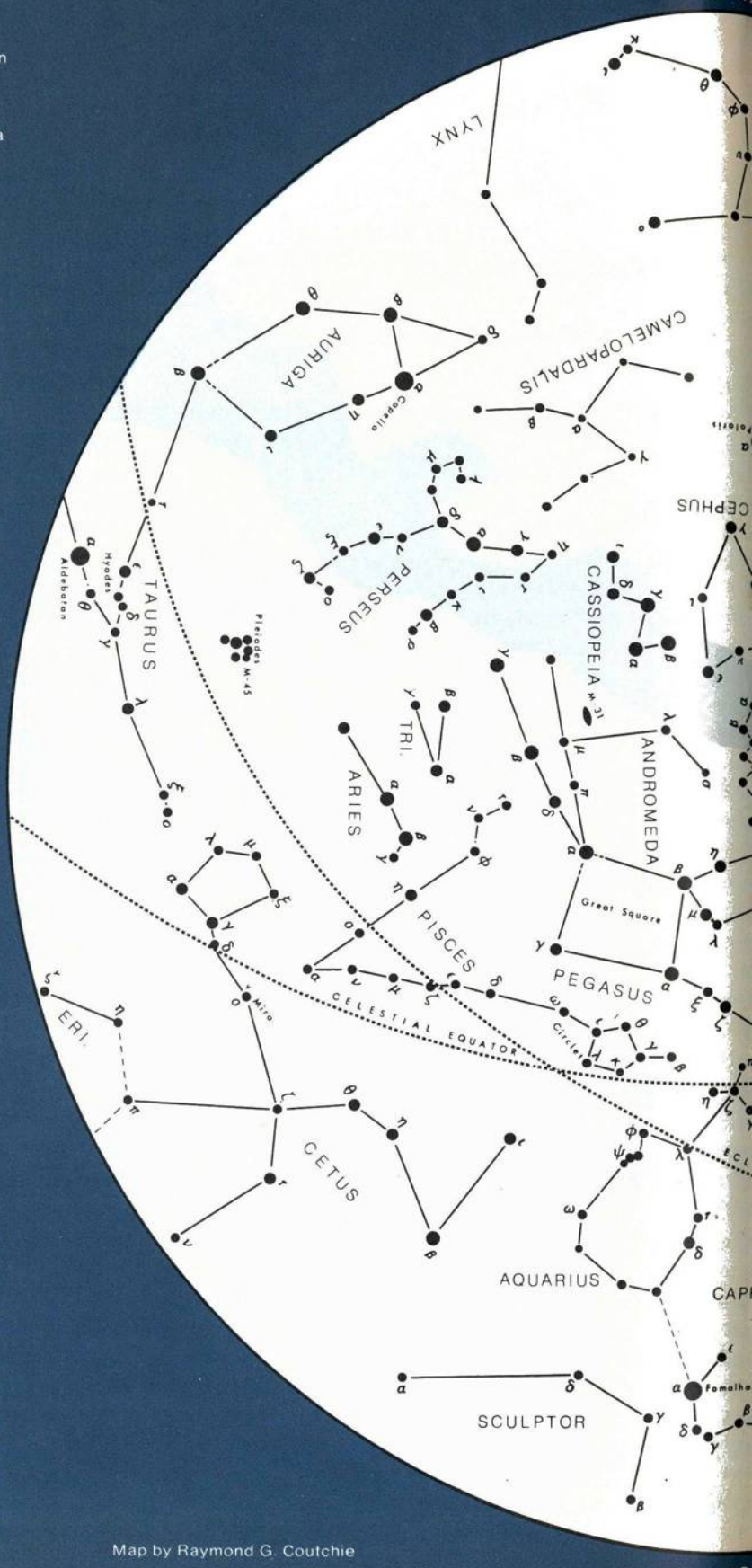
α	Alpha	η	Eta	ν	Nu	τ	Tau
β	Beta	θ	Theta	ξ	Xi	υ	Upsilon
γ	Gamma	ι	Iota	o	Omicron	ϕ	Phi
δ	Delta	κ	Kappa	π	Pi	χ	Chi
ϵ	Epsilon	λ	Lambda	ρ	Rho	ψ	Psi
ζ	Zeta	μ	Mu	σ	Sigma	ω	Omega

MAGNITUDES

- Zero
- First
- Second
- Third
- Fourth
- Fifth

OBJECTS

- Open Clusters
- Globular Clusters
- Diffuse Nebulae
- Galaxies
- Double Stars
- Variable Stars

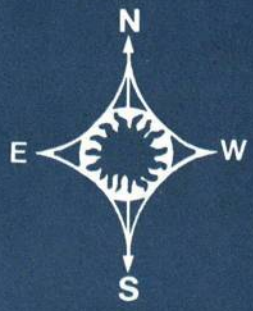


Map by Raymond G. Coutchie

Star Dome approximates the sky as it appears at 10 p.m. Local Daylight Time on the first day of the current month. The same constellations are visible one hour earlier on the 15th. To use this constellation finder, hold it overhead so the compass points line up with North, South, East and West in your backyard or viewing area. For example, to find constellations in the southern part of the sky hold the chart in front of you so the South compass point faces the southern horizon. Repeat this procedure for East, West and North. Since only the brighter stars are represented in this map, you should be able to trace out the geometrical shapes of the constellations with ease. To find planets, asteroids, etc., visible among the current month's zodiacal constellations, refer to the planet finder in Sky Almanac.

STAR DOME

Map Centered on 43° North Latitude



by

John G. Harmon

Looking toward the south this month we find an area of the sky known to the ancients as "The Sea". The area includes the constellations Aquarius, Capricornus, Cetus, Delphinus, Eridanus, Pisces, and Piscis Austrinus. The watery connotation of these constellations dates back to the time when the sun was in this area of the sky during the rainy season of the year. Near the middle of this area is the constellation Aquarius the Water Carrier.

Aquarius was pictured by most cultures as a

water bucket or jar, either alone or carried by a man or boy. The Arabs, however, envisioned the bucket being carried by a mule because the Islamic religion forbade depicting a person among the stars. The jar itself is marked by a prominent "Y" shaped asterism formed by the stars Gamma, Zeta, Eta, and Pi Aquarii. The constellation has always been associated with rains and floods as in Egypt, where the annual flooding of the Nile was believed to be caused by Aquarius, who was dipping his jar into the Nile's waters.

In Greek legends, the constellation is said to represent the boy, Ganymede, who was the son of Tros, King of Troy. Because of his beauty he was chosen to replace Hebe as the cup bearer to the gods. He was carried to Mt. Olympus by Jupiter in the form of an eagle which is said to be represented by nearby Aquila.

Another possibility, more in keeping with the constellation's watery nature, is that Aquarius represents Noah, placed in the sky as a reminder of the flood.

Aquarius can truly be said to contain some lucky stars. Alpha Aquarii is named Sadalmelik which means "lucky one of the King". Beta is Sadalsuud or the "luckiest of the lucky", and Sadachbia or Gamma is the "lucky star of hidden things".

Below Aquarius is Piscis Austrinus, the Southern Fish, which is generally shown drinking the water pouring from the Water Carrier's jar. There is no major myth concerning this constellation, and it has been said to represent everything from the parent of Pisces (the northern and western fish) to a fish with a coin in its mouth that was caught by Saint Peter.

The brightest star in this group is Fomalhaut (pronounced Fō-mal-ō) which means the fish's mouth. This conspicuous first magnitude star is the only bright star in this region of the sky. Fomalhaut was one of the four Royal Stars of Persian astrology along with Regulus, Antares and Aldebaran. These stars ruled the cardinal points with Fomalhaut marking the south or winter solstice over 5,000 years ago.

Also a part of the "Sea" is the zodiacal constellation Pisces the fish. It is pictured as two fish tied together by their tails with a long cord or ribbon. The western fish is marked by an asterism known as the circlet, while the northern fish consists of a group of fourth and fifth magnitude stars located below Andromeda. Alpha Piscium is named Al Rischa or the cord, and it marks the spot where the cords around the fish's tails are knotted together. Names descriptive of their position in the constellation can be found for some of the other stars in the group.

In Greek mythology, Pisces represents Venus and Cupid and was sometimes popularly known by that name. It commemorates a time when Venus and her son dove into the Euphrates River, transforming themselves into fish to escape the giant Typhon. This story is in many ways like one of the myths about Capricornus the sea goat who is said by some to represent the god Pan, who took similar action when he too was confronted by Typhon.

The northern fish is sometimes said to be the monster sent to devour Andromeda. In this respect, it is closer to Andromeda than the constellation Cetus. Cetus, which is also in the "Sea" traditionally represents a sea monster.

Just outside the "Sea", but closely related to Aquarius and Pisces, is Aries the Ram. This small constellation does not resemble a ram in any way and hence appears to be more symbolic in nature. Aries is said to be the ram with the Golden Fleece. This is the ram that carried Phrixus and Helle away from their cruel stepmother. Unfortunately, while flying over the Dardanelles, Helle lost her grip and fell into the water which is why that strait was formerly known as the Hellespont. The fleece of the ram was hung in the sacred grove of Ares (Mars) where it later became the goal of Jason and the Argonauts.

Aries is related to the constellations Pisces and Aquarius by the vernal equinox. This point in the sky where the sun stands on the first day of spring was in Aries from about 1730 B.C. to 420 A.D. Aries then bore the Latin titles Princeps Signorum Coelestium (Prince of the Celestial Signs), Princeps Zodiaci (Prince of the Zodiac), and Ductor Execitus Zodiaci (Leader of the Hosts of the Zodiac).

Precession has brought the vernal equinox to its current position in Pisces (near the star Omega) and is moving it towards Aquarius, bringing about the dawning of the so-called Aquarian Age.

In his book **Hamlet's Mill**, Giorgia de Santillana points out an interesting correlation between religious symbolism and the position of the vernal equinox. "The advent of Christ the Fish marks our age. The preceding age, that of Aries, had been heralded by Moses coming down from Mount Sinai as 'two-horned'; that is, crowned with the Ram's horns, while his flock disobediently insisted on dancing around the 'Golden Calf' that was, rather, a 'Golden Bull', 'Taurus." It is interesting to speculate on the symbolism inherent in Aquarius the Water Carrier.

KOHOUTEK: Great Comet of the Century

by

Terence Dickinson and James A. Louden

Everyone has heard of Halley's Comet. It's as famous as the rings of Saturn and "canals" of Mars. But now there's a chance that a new comet may rival Halley's enduring fame.

Comet Kohoutek is predicted to exceed in brightness and visibility every comet since 1882, including Halley's. Just how bright it will be depends on several factors, but one thing is certain — this December and January a naked eye comet will be in our skies.

The last reasonably bright comet to grace Earth's sky was Comet Bennet, visible in the early morning skies of March 1970. Before that, Comet Ikeya-Seki was a spectacular sight in 1965 from latitudes below 30 degrees north. The last really good comets seen from upper northern latitudes were Mrkos and Arend-Roland (both in 1957).

Actually, a dozen or more comets pass by our part of the solar system each year, but these are most generally faint objects not visible in amateur-sized telescopes. Kohoutek is a giant among comets at least 100 and perhaps 1,000 times larger than the average observed comet.

The average comet is a mile-wide, frozen ball of dust and gas that has probably never come anywhere near the sun. Such a body would, of course, be invisible even in the largest telescopes. It is usually only when a comet is perturbed into an orbit that carries it within the orbit of Mars that it becomes detectable.

During the three months or so when the comet is inside the orbit of Mars, the sun's radiation causes spectacular changes. The comet's outer layers are vaporized forming the head — a cloud of highly rarified gases about 100,000 miles in diameter. Nearer the sun, more melting enlarges the cloud but instead of expanding uniformly in all directions, most of it streams away in a tail that may stretch tens or hundreds of millions of miles into space.

The tail, consisting of gas and dust, always points away from the sun. This is because the solar wind (a steady stream of protons and electrons from the sun) is sufficiently strong to push the gas away from the meager gravity of the tiny solid part of the comet. The dust is pushed away by the pressure of sunlight itself.

COMET KOHOUTEK POSITIONS

OCT. 5 - NOV. 9

Date	Right Asc.	Dec.
Oct. 4	$10^h\ 36^m$	$-1^\circ\ 25'$
14	10 44	-3 29
24	10 16	-5 56
29	11 28	-7 17
Nov. 3	11 42	-8 39
8	11 56	-10 20

TABLE A

COSTANZO

If the comet passes within a few hundred thousand miles of the sun it can lose one percent or more of its material — a loss that results in a brief but usually spectacular tail.

A minimum distance of several million miles produces a significant tail formed from about one-tenth of one percent of the comet. If the comet never comes within the orbit of Venus it sheds little of itself and is usually quite unspectacular.

Comets do not look like their photographs — a fact that should be explained in the caption of every comet photo but never is. So don't expect Comet Kohoutek to look like what you've seen in your favorite astronomy book.

The typical comet photograph shows a featureless head of uniform brightness and a straight or fan-shaped tail which often appears the same intensity as the head. The tail usually has complex, delicate structure along the edges. There may also be a dull, structureless, curved second tail (especially in modern photos), but the one that draws your attention is the brighter one.

To the naked eye or through a telescope the head is not uniformly bright — it increases in brightness greatly toward the center, and has an almost starlike core. In fact, to the unaided eye the head looks very much like a star that is blurred as if seen through a mist. Furthermore, the tail is curved, noticeably fainter than the head, and shows little structure. Occasionally, delicate lengthwise striations make the tail look like a bundle of about a half dozen wisps of hair. Indeed, a comet may look exactly like the ancient description from which our word "comet" is derived: stella cometes, Latin for hairy star. Visually, both head and tail are yellow if the comet is bright enough to see colors. On the other hand, a color photograph will probably record yellow as well as a good deal of blue which the eye doesn't see.

Why the differences? Comets have a very broad range of brightnesses from their brightest to faintest parts. The eye is able to perceive a much greater brightness range than any single photograph. However, if exposed long enough, a photograph can record faint detail well below what the eye is able to see. Recording faint detail is achieved at the cost of overexposing all the brighter areas of the comet. It happens that long exposure photographs are the most spectacular and are thus chosen to illustrate popular books. In such pictures, the brighter areas of the head and inner tail are completely overexposed — they appear featureless and pure white. The eye, with its ability to see a large brightness range, can detect detail within these regions. In a photograph, on the other hand, faint detail in the outer parts of a comet is not visible to the eye at all. The eye sees only the inner regions which the photograph overexposes.

COMET KOHOUTEK DISTANCES FROM EARTH AND SUN

Date	Distance from Earth	Distance from Sun
Oct. 4	258	185
24	211	153
Nov. 3	187	134
23	139	97
Dec. 3	124	68
18	106	37
23	106	22
28	103	13
Jan. 2	90	25
7	80	41
12	78	55
22	81	78
Feb. 1	94	99
21	139	136

TABLE B

The dust and gas in a comet's tail often separate to form two tails. The dust gives a comet its yellowish appearance while the gas shines in the blue or invisible ultraviolet. The eye is very sensitive to yellow light, but relatively insensitive to blue, especially at low light levels. Naturally, ultraviolet can't be seen at all.

Essentially what the eye sees is the dust tail while the gas tail is very faint at best. Photographic emulsions used at most observatories operate in just the opposite manner. So what we find in most comet photographs is actually the gas tail, and the dust tail is barely recorded.

Searching for comets requires a large telescope, clear sky, the patience of a saint and considerable knowledge of the sky. For best results,

On the evening of January 8, 1974, about one hour after sunset, Comet Kohoutek will be just above Venus and to the right of Jupiter. The precise appearance of the comet is unpredictable but in the rendering at left, artist Victor Costanzo of the Strasenburgh Planetarium shows it as it will be seen if it lives up to some of the more optimistic predictions. If it is this bright, it will be the most spectacular comet visible from northern latitudes since 1882.

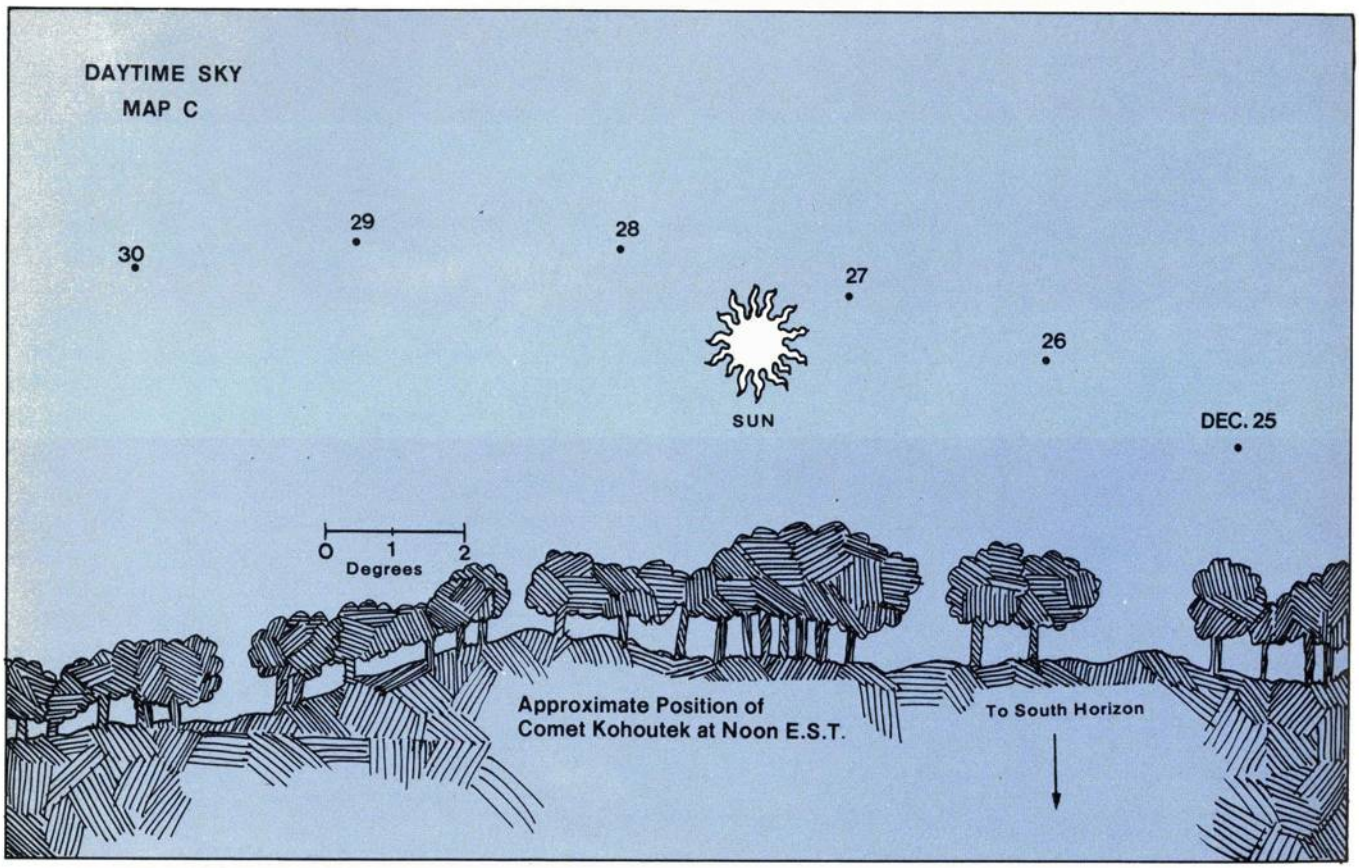
a six or eight inch, richest-field telescope is necessary. The eyepiece should be low power with as wide a field of view as possible. Most comet hunters use scopes with very fast optics in the f/5 range. Since it takes an average of 300 hours to locate a comet, you can expect to sweep the skies many times before you find one — if at all. Finally, thorough knowledge of the sky is necessary to detect the difference between a gas nebula, globular star cluster and a comet. They all look very similar in an eyepiece.

Few observers discover more than one comet in their lifetimes. However, in recent years there has been a hard core of dedicated Japanese amateur astronomers who have found almost half the total number of comets discovered.

Comets are named for their discoverers, a practice that encourages people to search for them. Sometimes, however, this practice leads to confusion. For example, "Comet Kohoutek" generally means Comet 1973f ("f" being the sixth comet discovered in 1973). As it turns out, the preceding comet — Comet 1973e — was discovered by the same man and is, therefore, also called Comet Kohoutek! With this confusing situation one need not wonder why astronomers adopted the letter system for identifying comets. Under this system, the first comet discovered in any given year is lettered "a"; the second "b", and so on to the 26th, "z".

Observers may be interested to know that on the statistical average a naked eye comet is visible every two or three years. Every 10 years or so, the skies are visited by a bright comet with a strong naked eye tail. Only two or three times per century does a really spectacular comet enter our solar system. These marvels become so bright that they are visible in the daytime sky.

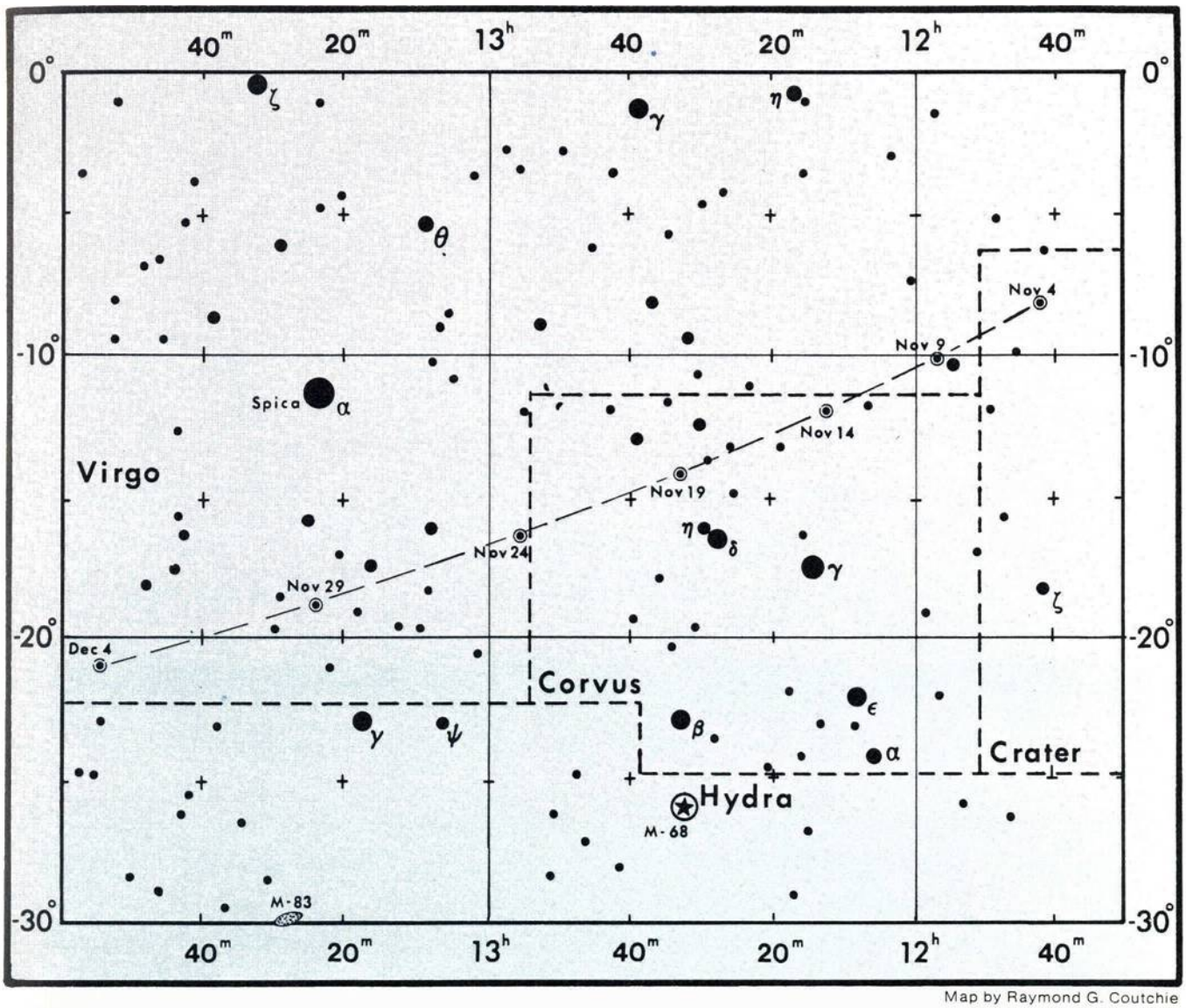
So far during the 20th century, two daylight comets have graced our sky. These were Comet 1910i and Comet Ikeya-Seki which appeared in 1965. Since Ikeya-Seki was visible in daylight for only one day, it barely counts as the 20th century's second most spectacular. This year, Comet Kohoutek may be the century's most spectacular.



If Comet Kohoutek becomes a daytime object (magnitude -7 or brighter) then it will be possible to see it without optical aid using this chart. First, get the sun behind a pole so that your face is in the shdaow. Then search the sky in the area indicated for the date. The comet is expected to be brightest on December 28. The sky must be free of high clouds and haze. Do not use optical aid — the danger of accidentally looking at the sun is too great.

COMET KOHOUTEK FOR NOVEMBER

MAP A



Map by Raymond G. Coutchie

Magnitudes

- Zero
- First
- Second
- Third
- Fourth
- Fifth

Objects

- Open Clusters
- Globular Clusters
- Diffuse Nebulae
- Galaxies
- Double Stars
- Variable Stars

As Comet Kohoutek approaches the sun it should reach naked eye visibility in early November. Spica and Corvus will be useful guides in identifying the comet as it moves between them. About 1-1/2 to 2 hours before sunrise is the time to use this chart. Binoculars will be helpful if the comet is faint or the sky hazy. For positions for October see Table A.

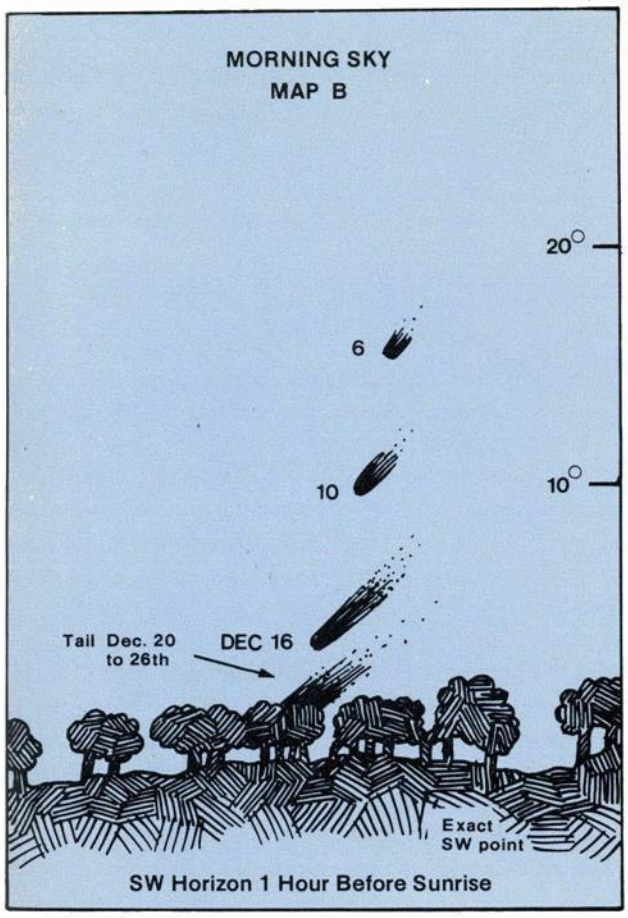
COMET KOHOUTEK OBSERVER'S GUIDE

***The magnitudes given here are estimates of the brightness of the entire comet, not just the coma. Estimates available from other sources may be much higher than these but such values are based on optimum factors and seldom prove accurate.**

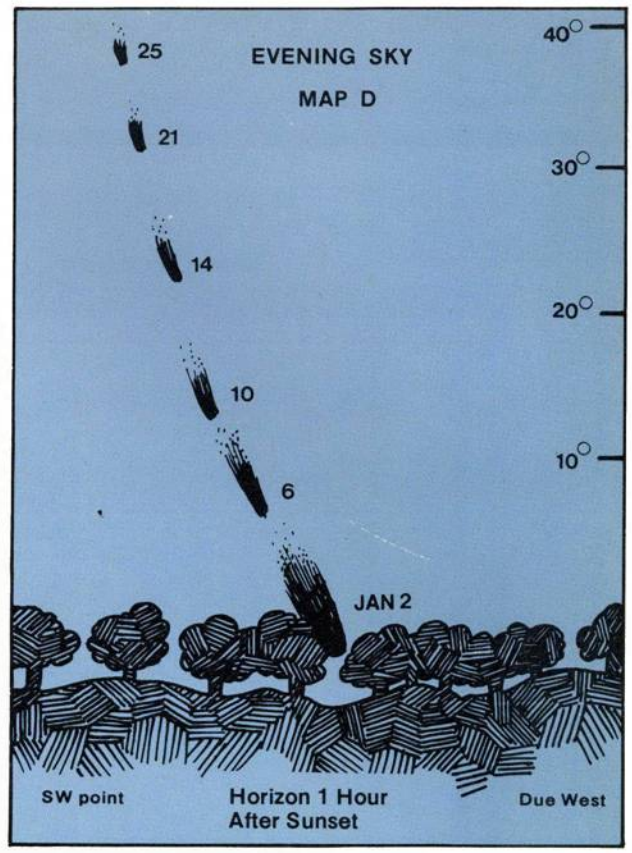
Date	Magnitude	Remarks
Oct. 10 - 25	+9 to +7	Visible in telescopes 60mm and larger as a hazy patch like an unresolved globular cluster. See table A.
Oct. 25-Nov. 10	+7 to + 5	Binoculars should be enough to identify the still "fuzz-ball" shaped comet. See table A.
Nov. 10 - 30	+5 to +3	Comet should now be a naked eye object and show evidence of a tail. If tail is well developed by November 30 then a real spectacle is due in December and January. See map A.
Dec. 1 - 5	+3	Rapid motion toward the sun begins here. See map A.
Dec. 6 - 10	+2	Comet should now be an easy naked eye object with tail streaming up and to the right. See map B.
Dec. 11 - 15	+1	Moon interferes here as comet brightens but still several degrees above horizon in dark sky. See map B.
Dec. 16 - 20	-1	Although predicted magnitude is bright, twilight begins to seriously interfere with viewing. If tail is long it may show above horizon haze or lights. See map B.
Dec. 21 - 27	??	Comet's head lost in twilight, but tail may be on southeast horizon extending upward and to the right at a 45 degree angle.
Dec. 25 - 31	??	If magnitude -7 or greater is reached, the comet will be a naked eye object. See map C.
Dec. 29-Jan. 1	??	Tail is expected to be maximum brightness now. Head of comet in twilight but tail may remain as darkness falls. Tail will reach upward and to the left at a 60 degree angle above the west-southwest horizon.
Jan. 2 - 16	-2 to +1	This is the prime period for observation. See text and map D.
Jan. 17-Feb. 1	+1 to +4	Comet should be an easy object in the dark evening skies with tail still visible. See map D.
After Feb. 1	below +4	Visible in binoculars and telescopes for several months. See future issues for details.

Comet Kohoutek 1973f was discovered March 7, 1973, by Dr. Lubos Kohoutek, a Czech-born astronomer now working in Germany. He was previously best known for work in the field of planetary nebulae. Both 1973f and 1973e were discovered accidentally on photographic plates taken for entirely different reasons. In most cases nowadays when a professional astronomer discovers a comet, it turns out to be this sort of accident. The only people actively engaged in hunting for comets are amateur astronomers.

At the time of discovery, Comet Kohoutek was very faint. It was only visible through the largest telescopes, and of course it had no tail. In fact, it was thoroughly unremarkable except for one thing — it shouldn't have been visible at all. When Dr. Kohoutek discovered the comet, it was nearly half a billion miles from the sun — just inside the orbit of Jupiter. If it was that bright that far away, astronomers reason that it should be extremely spectacular on December 28 when it reaches its minimum distance from the sun of only 13 million miles.



The length and shape of Comet Kohoutek's tail is unpredictable, but this chart approximates what one can expect to see. The height of your outstretched fist is equal to about 10 degrees and serves as a portable version of the scale on the right edge.



January 1974 should be the finest period for viewing Comet Kohoutek from the northern hemisphere. The length and shape of the tail are unpredictable but there is little doubt that the comet will be an easy naked eye object. On January 8 the comet will be very near Venus and Jupiter (see artist's rendering, page 28).

There is another consideration, however. To be spectacular, a comet must not only be bright, it must have a large naked eye tail. No matter how bright it is, the head is a relatively small object in the sky, so it doesn't look very much different from a star. This means a large dust tail is necessary for a comet to be seen well. For reasons already stated, the gas tail is nearly invisible no matter how big it may be. Comets vary greatly in the amount of dust they contain (nobody knows why), and if the comet has never been seen before, there is no way to predict the amount of dust it contains.

With Comet Kohoutek, we won't know how bright it will be until the tail starts developing in late October or early November. Even if it turns out that only the head is visible, the comet will still be an easy naked eye object — but it certainly won't be as memorable.

AUTHORS

Carl Sagan — Dr. Sagan is director of the Laboratory for Planetary Studies and professor of astronomy and space sciences at Cornell University.

He received his A.B., B.S., M.S. in physics and his Ph.D. in astronomy and astrophysics, all from the University of Chicago. He subsequently served as Miller Research Fellow in the Institute for Basic Research in Science of the University of California, Berkeley; as assistant professor of genetics at Stanford University Medical School; as astrophysicist at the Smithsonian Astrophysical Observatory and as assistant professor of astronomy at Harvard University. He has been a National Science Foundation Fellow, an Alfred P. Sloan Research Fellow at Harvard (where he received the A. Calvert Smith prize in 1964), and the Condon Lecturer for 1967-68 at the University of Oregon. He is a recipient of NASA's Apollo Achievement Award (1969) and Exceptional Scientific Achievement Medal (1972).

Dr. Sagan's principal research activities are in the physics and chemistry of planetary atmospheres and surfaces, space vehicle exploration of the planets, and the origin of life on Earth. He is also known for his studies in exobiology, the emerging discipline which deals with the possibility of extraterrestrial life and the means for its detection.

Dr. Sagan serves on many advisory groups to the National Academy of Sciences and NASA. He played a major role in obtaining the first close-up photos of the moons of Mars, and in studying surface changes on that planet from the Mariner 9 spacecraft. He was responsible for placing aboard the Pioneer 10 spacecraft the first man-made object to leave the solar system, the first message intended for possible extraterrestrial civilizations.

He was leader of the U.S. delegation to the Conference on Communication with Extraterrestrial Intelligence, organized jointly by the U.S. National Academy of Sciences and the Soviet Academy of Sciences in Armenia in 1971. Vice President of the working group on the moon and planets of the international space organization, COSPAR, and an officer of the planetary commission of the International Astronomical Union, he is also chief editor of ICARUS, the international journal of solar system studies.

In addition to over 150 published scientific articles and papers, and several contributions ("Life", "Mercury", "Venus") to the **Encyclopedia Brittanica**, Dr. Sagan has authored, co-authored and edited numerous books on space and planetary research and phenomena, and extraterrestrial life.

Robert W. Provin — Mr. Provin is Staff Cartographer in the geography department at the California State University, Northridge, Calif.

He first became seriously involved in amateur astronomy through the American Association of Variable Star Observers (AAVSO). For the last 10 years, his primary interest has been astrophotography.

James A. Louden — Mr. Louden is chief demonstrator at the Exhibit Museum Planetarium and an astronomy lecturer at the Residential College, both of the University of Michigan in Ann Arbor.

A native of Philadelphia, Mr. Louden received his M.A. in astronomy from the University of Michigan.

Brad D. Wallis — A part time staff member of the Griffith Observatory in Los Angeles, Calif.

Mr. Wallis is presently working on a comprehensive book on astrophotography in theory and practice.

For nearly 10 years, Mr. Wallis has studied and applied various processes used by both amateurs and professionals to obtain better astrophotographs.

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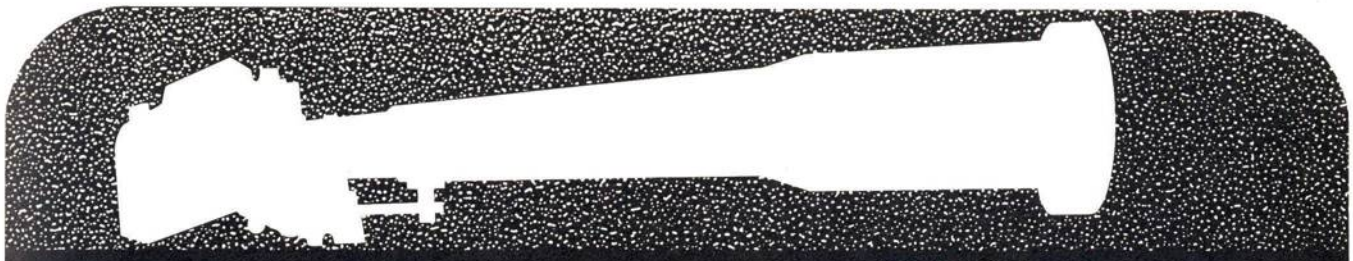


INTEGRATION PRINTING: An Aid to Long Exposure Astrophotography

by

Brad D. Wallis
Griffith Observatory

&

Robert W. Provin
Polaris Observatory Association

(Editor's Note: Frequently, advanced astronomy enthusiasts become frustrated when they are unable to obtain observatory quality astrophotographs. This is primarily due to the fact that amateur telescopes are quite small. Until recently, amateurs believed telescope, camera and film were the end criteria in obtaining impressive photos. Now, however, there are a variety of specialized darkroom techniques that can open a whole new dimension to amateurs in their quest for quality astrophotographs. One rather technical method called Integration Printing is here outlined by Brad Wallis and Robert Provin.)

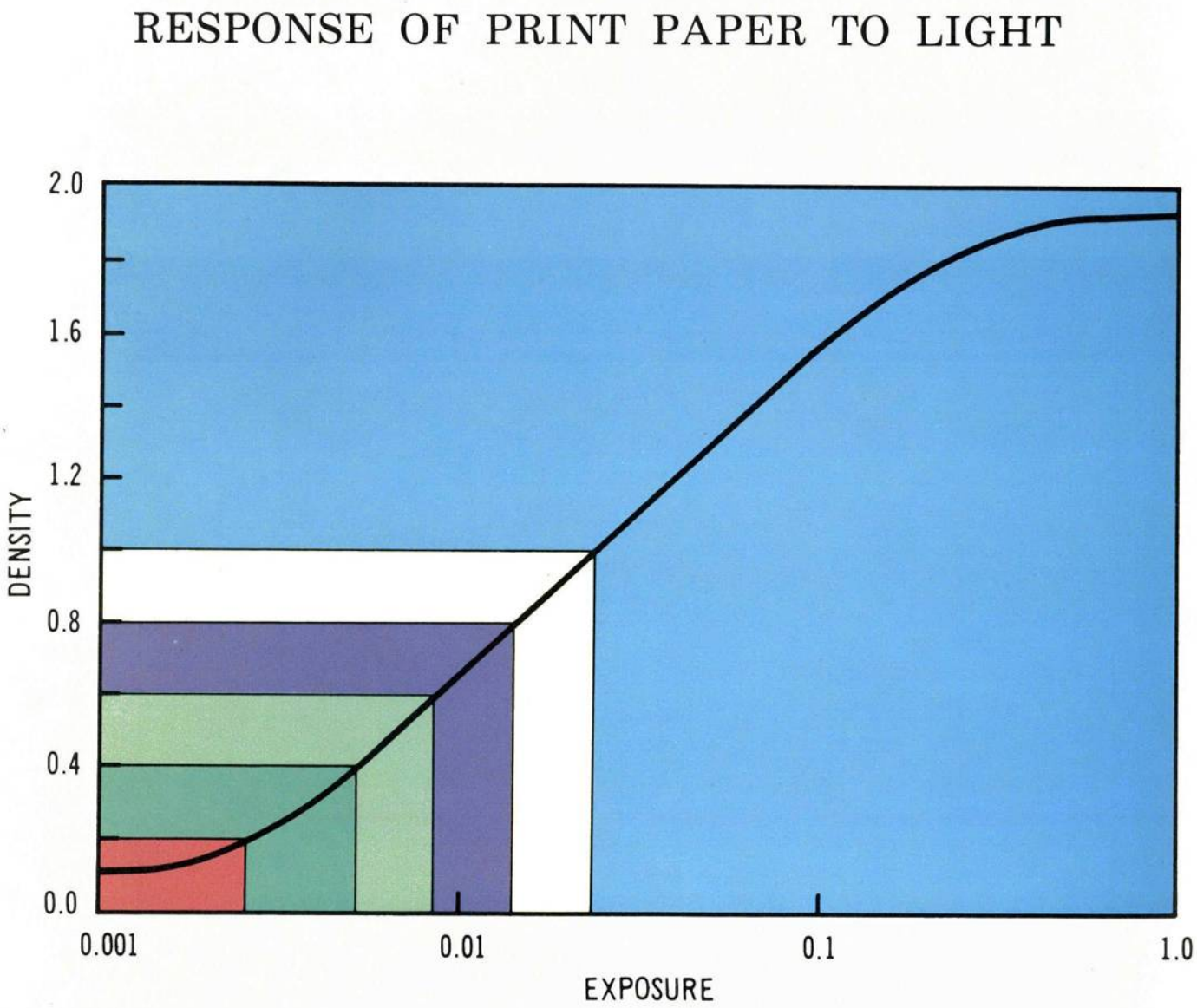
Photography has been one of the astronomer's most important tools since about the turn of the century. Since their introduction into astronomical use, photographic emulsions have been greatly improved. Specifically, the problem of speed and low intensity reciprocity failure have been significantly improved in the past two decades. But the plaguing problem of granularity, inherent in all film, still remains.

Solutions to this problem have been sought by creating semifine-grained film such as the new Kodak IIIa-J emulsion. Unfortunately, films as supplied by the manufacturer are substantially

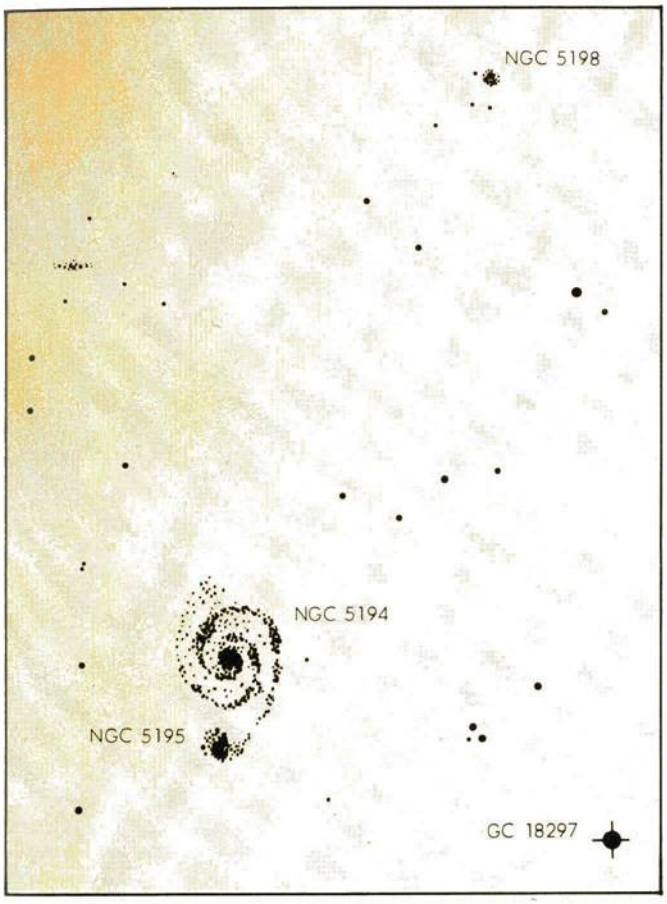
slower than the standard 103a and IIa emulsions. In addition, they are not available in the numerous spectral sensitivities that characterize these standard emulsions. The technique outlined in this article will allow advanced astrophotographers to produce fine-grained results using standard emulsions and will also show how to improve the results obtained with the new IIIa emulsions when they become available in different spectral sensitivities.

The technique has been known since 1926, but remained little used for quite some time. Today it is widely used in professional astronomy for both planetary and deep sky photography.

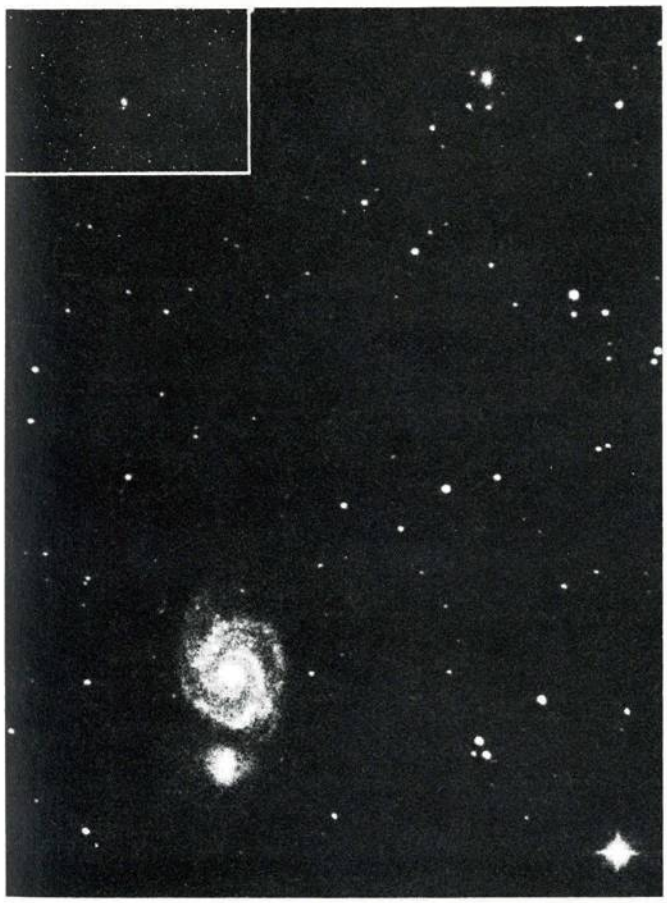
The name for the technique, Integration Printing, was coined by William C. Miller, head of the photographic department of the Hale Observatories. It is based on the fact that the distribution of silver grains in photographic emulsion is a



This graph is a representative "characteristic curve" illustrating the response of a print paper to light. The lines plotted on the diagram demonstrate why the first negative used in Integration Printing must be exposed slightly longer than with succeeding negatives if the first is to contribute equal density to the final image. Numbers used here are relative and only serve to illustrate the need for more exposure with the first negative. See article for more details.



The map at left shows the star field in the M-51 photographs on the bottom of this page. The bright star at the lower right edge is GC 18297 (Boss General Catalogue number) which is magnitude 6.9 located at R.A. 13h 29' 50.3" and Dec. +47° 29' 28" (Epoch 1950). A small galaxy is found in the upper right hand corner — NGC 5198 at magnitude 12.9. The small needle-like galaxy near the upper left edge does not have a catalogue number and is probably near magnitude 14. At the bottom of the page, the left hand photograph is an unintegrated 20 minute exposure taken with a six inch f/4 reflector telescope on Kodak emulsion 103a-E. The two fainter galaxies found in the above map are also faintly visible. The small cutout in the upper left corner of this photograph shows the original size of M-51 before enlargement. The right hand photograph is an integrated print in which six 20 minute exposures were used to produce a single, high-resolution photograph. Notice the apparent lack of grain, and the added details in the spiral arms and nucleii of M-51. The filaments connecting the spiral arms are also more easily seen. Notice also that the two fainter galaxies in the upper portion of the photograph are now well defined and can no longer be taken as flaws in the negative.



The upper photograph is a 20 minute exposure of M-43 in Orion. It was made with a six inch f/4 reflector telescope stopped down to f/5.6 in order to increase the size of the coma free field. This photograph which has not been integrated was made on Kodak emulsion 103a-F and processed for nine minutes in MWP-2 developer at 68 degrees Fahrenheit. Right is an integrated print in which three 20 minute exposure negatives were used to produce this fine-grained print containing increased resolution. Notice the increased contrast in the central portion of the nebula where the dark lanes are present.

perfectly random one. As a result, by "sandwiching" the emulsion grain patterns from two or more negatives of the same object, the granularity of the image is reduced and detail enhanced. Due to the random nature of grain distribution in the photographic emulsions, by using this method detail which falls on less sensitive silver grains in one negative or on coarser grain in another can be "recovered".

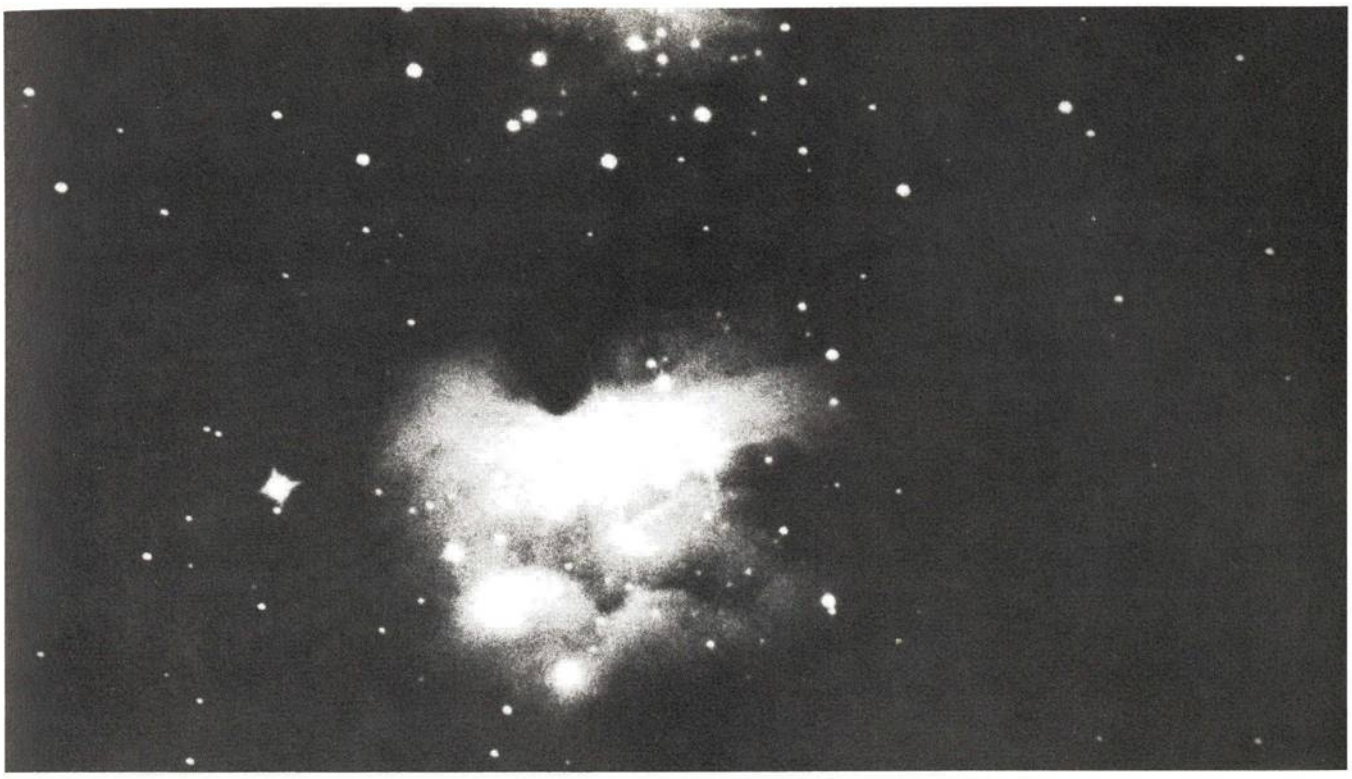
The portion of the image which is recovered is referred to as an "information gain". Earlier studies have shown that this information gain (detail recovery) is proportional to the square root of the number of negatives being integrated. Another aspect of detail recovery is an increase in the limiting magnitude of an integrated print as compared to a print made from a single negative. In a 1959 study at Lowell Observatory it was found that a 1.2 magnitude gain was obtained when 10 negatives were integrated.

There are two major points to keep in mind with Integration Printing. First, the total length of the integrated exposure must be about 25 percent longer than the exposure needed to print a single negative. This is due to the fact that a series of exposures is being made instead of one continuous one. The effect is known as the Intermittency Effect. Second, the exposure used in printing the first negative must be slightly longer than the exposures given each of the succeeding negatives. This is necessary due to the fact that the response of photographic papers to light is not linear. (See graph on page 36.)

To do Integration Printing construct a printing easel with a hinged opaque cover. The cover top should be painted with white enamel so it can be easily seen under the enlarger and written on with pencil.

Let's say, by way of example, that five negatives will be integrated. The first negative is placed in the enlarger, focused as usual and the printing easel adjusted for composition. Next, with the enlarger turned off, print paper is taped to the easel board and the hinged cover swung into place over the paper. The enlarger should be turned on again and the positions of three to five stars marked in pencil on the white cover top. The step is necessary to provide perfect register for the integration of the five negatives.

The first negative may now be exposed. To



determine the integration exposure for all five negatives, make a normal print with full range of densities from the first negative. If, for example, an exposure of 60 seconds is needed to produce a normal print, 15 additional exposure seconds (25 percent more exposure) must be added to arrive at a total integration exposure to compensate for the Intermittency Effect.

This means that the five negatives to be integrated would have to be exposed for a total of 75 seconds, or 15 seconds each.

Further, to accomodate the characteristic response of the printing paper to light, the first negative requires an exposure of 15 seconds plus 25 percent. As indicated earlier, the first exposure must be the greatest. In the example here, the first negative would be exposed an additional 3.75 seconds for a total first exposure of 18.75 seconds.

The second, third, fourth and fifth negatives should each in turn be registered carefully on the easel cover and then exposed for 15 seconds.

Integration Printing is particularly useful for photography of small objects and objects with extended detail at or near the magnitude threshold of the film. The technique allows for the display of detail not available on a single negative, and at the same time causes marked decrease in graininess.

Following are six additional tips to help readers with Integration Printing:

1. A coma free field (on the printing easel) of at least five inches is a desirable aid in the accurate registration of the negatives. Further, using stars at the edge of the print, but within the coma free field, as well as stars near the limitation magnitude of the film also aids registration.

2. All negatives should be of the same density. Minor variations can be compensated for by slightly varying the exposures used in printing.

3. All negatives should be taken under equivalent seeing conditions. An image blurred by poor seeing will degrade contrast and result in a noticeable loss of detail.

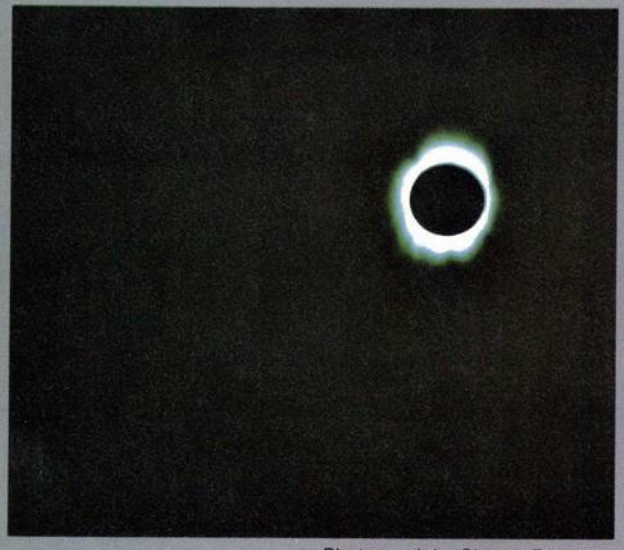
4. The contrast of the final integrated print will seem to be less than that of a print made from a single negative. As a result, the best prints will be obtained by using paper having a higher contrast grade than is normally used.

5. While another study found that the integration of 10 to 15 negatives produced desirable results, an excellent gain in detail and grain structure can be obtained by integrating as few as three to six negatives.

6. It is important that the orientation of the diffraction spikes remains constant from negative to negative. Thus, if negatives are made on separate nights, it is necessary that the position of the telescope tube in the mount saddle remains constant.

Photograph by Raymond G. Coutchie

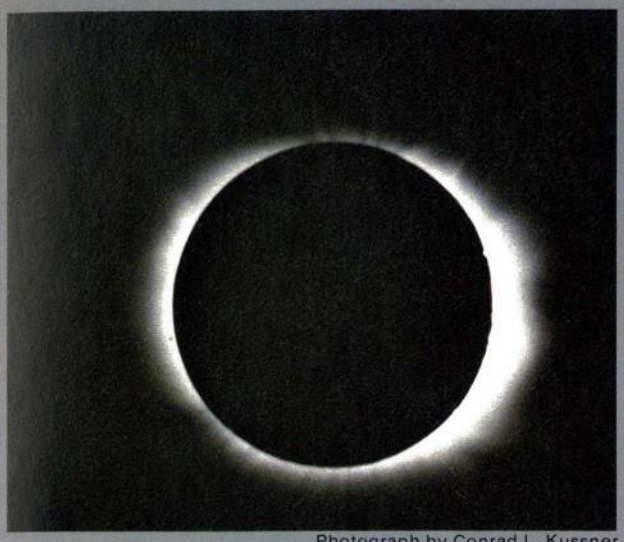
Photograph by George J. Flynn



Photograph by Sheran Brettman

This occasional department is devoted to some of the best color astrophotographs we receive over a period of months. They are generally made by amateurs with easily available equipment. Payment for use of these photos is $10.00 each.

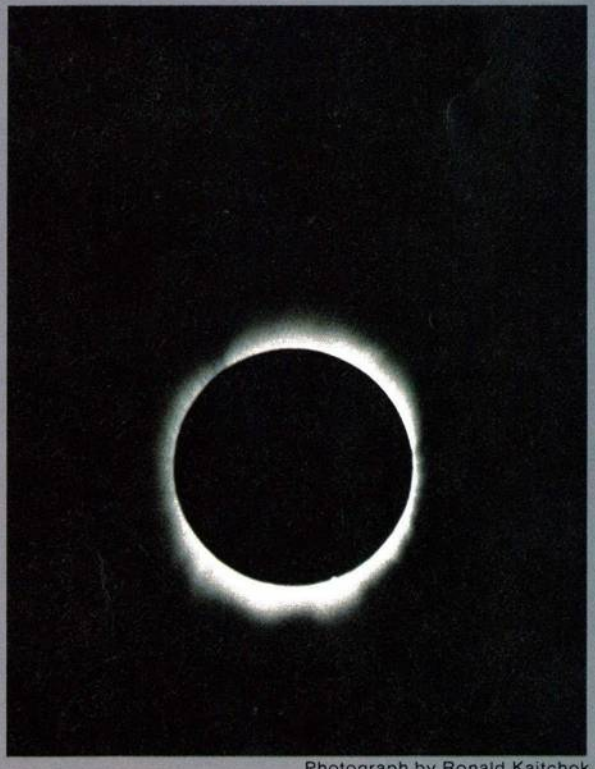
STAR GALLERY



Photograph by Conrad L. Kussner

Photograph by Tim Kilby

Photograph by Daniel A. Mitchell

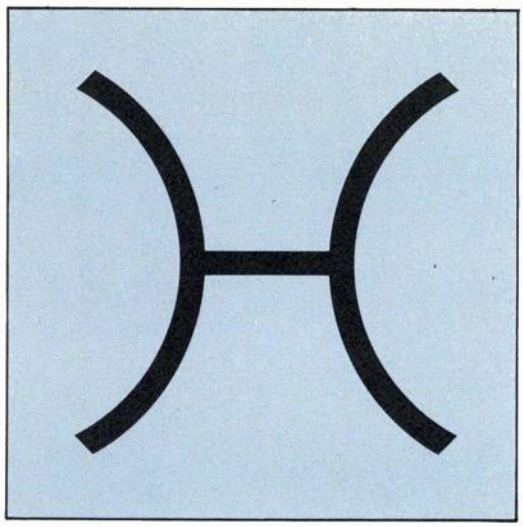


Photograph by Ronald Kaitchok

'73

CONSTELLATION CLOSE-UP

PISCES



by

Thomas C. Bretl

Due to the precession of equinoxes, Pisces has the inherited distinction, as heir to the ram, of containing the vernal equinox. Here, on March 22, the sun crosses the celestial equator on its annual northward journey and marks the coming of spring. As a nighttime constellation, however, Pisces rises high in the southeast in the evening hours of mid-October, and its approach toward the meridian marks the coming of fall.

Stretching along the southern boundaries of Andromeda and Pegasus, Pisces is another very large constellation of the Zodiac whose faintness betrays a wealth of good telescopic objects. Since it contains only one star as bright as third mag-

nitude, it may understandably go unnoticed by the naked eye observer, but several galaxies and double stars make Pisces an area well worth closer scrutiny.

Nebula enthusiasts will want to look first for M-74, one degree east of Eta Piscium. This galaxy is a broadside spiral and in observatory photographs looks much like the main part of the Whirlpool Galaxy, M-51. It is two magnitudes fainter than M-51, however, and often difficult to find in the glare of Eta. Some structural detail can be detected with an eight inch telescope, but only under excellent seeing conditions. This is an object that makes the observer yearn for that "slightly larger scope" (regardless of the size he already owns) so as to increase its contrast against the surrounding sky and enhance the beauty of its subtle, delicate structure.

Not far away, and three degrees northeast of Zeta Piscium, NGC 524, a small elliptical galaxy, can be found lying in a loose open cluster of eighth and ninth magnitude stars. Although one full magnitude fainter than M-74, it is almost as easy to spot because of its bright center and darker background. It lacks the tantalizing hint of detail found in the larger spiral, but adds an inspiring air of remoteness to an already striking low power field.

Piscean double stars offer observers contrasting colors and a wide range of separations in fields

TABLE OF OBJECTS IN PISCES

Double Stars

Star	Magnitudes	Sep.	Colors	R.A.	Dec.
35	5.9 - 7.6	11.8"	white-purple	00^h13^m	+ 8°39'
55	5.6 - 8.8	6.6"	yellow-blue	00^h38^m	+21°16'
65	6.0 - 6.0	4.5"	yellow-yellow	00^h48^m	+27°32'
77	6.8 - 7.6	33.3"	white-blue	01^h04^m	+ 4°45'
ζ	4.2 - 5.3	23.6"	white-gray	01^h12^m	+ 7°25'
α	4.3 - 5.2	2.1"	green-blue	02^h00^m	+ 2°37'

Galaxies

NGC	Messier Object	Mag.	Size	Type	R.A.	Dec.
524		11	3' x 3'	Elliptical	01^h23^m	+ 9°22'
628	M-74	10	8' x 8'	Spiral	01^h35^m	+15°38'

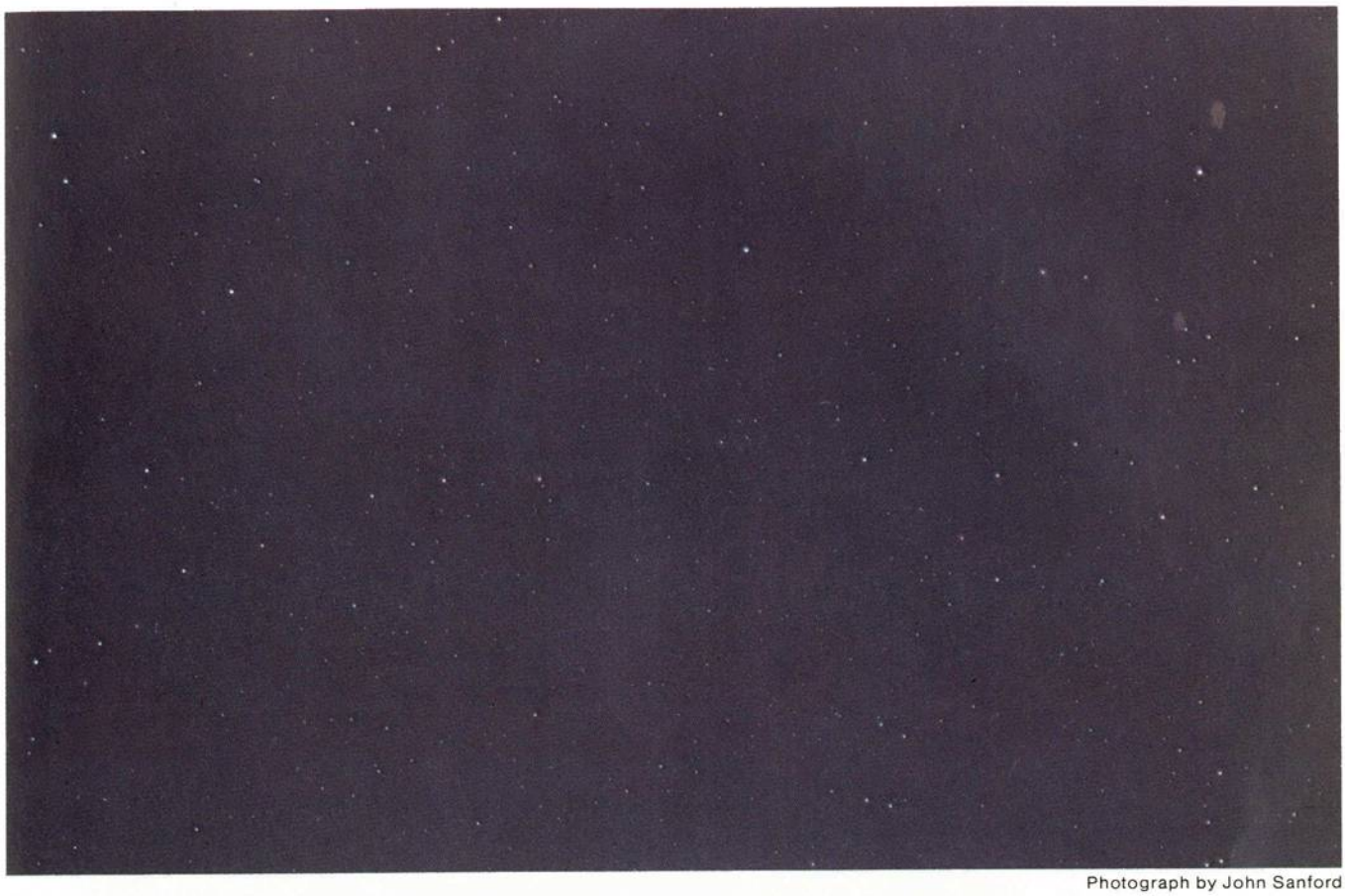
EPOCH 1970

Stellar Magnitudes -1 0 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 & fainter

Diffuse Nebula Double Stars Variable Stars ○

Galaxies Planetary Nebula ○ Open Star Clusters ☆ Globular Clusters ⊛

Map by Raymond G. Coutchie



Photograph by John Sanford

Because of its large size, Pisces is difficult to photograph. The above photograph shows the southern portion of the constellation with the Western Circlet quite evident. Through July, 1974, Constellation Close-Up will explore the constellations of the Zodiac. We ask our more proficient readers to submit their best constellation photographs to us as soon as possible. They should be in color and made with as large a camera format as possible (2-1/4 x 2-1/4 or 4 x 5). Be certain that the entire constellation is in the photograph including its IAU borders (consult a star atlas). The constellation Virgo will be covered in April, 1974. This is another very large and sprawling group, but it can be photographed with a little effort. Please submit a Virgo photograph by March 1, 1974. Our payment for constellation photographs in color is $10.00 each.

of varied richness. The colors are subtle. As difficult as it may be to describe their individual hues, observers will find the components' contrasts unmistakable. Zeta Piscium, for example, consists of two stars which individually could only be described as "whitish". When compared side by side, however, the fainter of the two takes on a definite grayish cast. More striking colors, on the other hand, are found in 55 Piscium, where the brighter component is a blazing orange, and the fainter component a delicate blue.

The separations of the double stars listed for Pisces range from a wide 33.3 seconds of arc, for 77, to a close 2.1 seconds of arc for Alpha, making them suitable "game" for an observer with any size telescope. At a separation of 4.5 seconds of arc, 65 Piscium is particularly interesting because its components have identical magnitudes and colors. Located in the northernmost part of Pisces, almost on the Andromeda border, 65 is also noteworthy as being part of a very rich field, especially when compared to the other doubles listed this month.

As Pisces reaches culmination, the Andromeda nebula is near the zenith, the double cluster in Perseus is high in the northeastern sky, and the Pleiades have already risen into observing position. In a normal year, it is easy to see why Pisces might be forgotten. This year, however, that will not be the case. Though many amateurs may never realize it, as Mars approaches the very favorable opposition of October 26, it will be moving westward through "lowly" Pisces, destined to remain there for most of the rest of the year. (See Sky Almanac.)

So while you're there anyway, observing the red planet, try some of the local attractions. Next year you may never think of it!

PUBLISHER'S MEMO

By now you've probably noticed a few changes from our first issue. The most obvious is the way ASTRONOMY arrives in your mailbox. Following a flurry of complaints about torn or demolished copies we decided it was advisable to wrap the magazine, thereby protecting it from the ravages of the Post Office.

If you look closely at the wrapper you will note that we indicate when ASTRONOMY is mailed. You see, not only is the Post Office destructive — it is slow! ASTRONOMY is mailed by the 20th of the month (sometimes earlier). We are told that second class mail is delivered in 10 days throughout the continental United States. However, as of August 23 we were still receiving complaints that the August issue had not been delivered (it was mailed July 20)! If your issue is late, armed with wrapper in hand, complain to your local Post Office. Then let us know, and we'll complain at this end.

The November issue of ASTRONOMY should be an interesting milestone in our short life. Effective with that issue we will expand the magazine from 48 to 64 pages, giving you 16 more pages of fascinating reading on astronomy. We will add three new departments — Letters to the Editor, Astro-News and Astro-Mart. Letters to the Editor is self-explanatory. But Astro-News will expand our horizons. This department will contain the most up-to-date news possible about astronomical developments, discoveries and space activities.

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This offer is not open to commercial advertisers. Since this advertising is free to noncommercial subscribers, we must reserve the right to edit or rewrite classified ads if necessary. To make our job easier, please keep your ads short (no more than 40 words), type them and be sure to include your full name, address and zip code.

We cannot acknowledge receipt of these ads nor promise to use them in specified issues of ASTRONOMY. Additional ads beyond the free limit of two will be charged for at the rate of 50¢ per word.

One final note. There is a severe paper shortage, and our printer advises us that we will be able to continue getting paper for ASTRONOMY if we change our size slightly. Effective with the November issue we will change from 8-1/2" x 11" to 8-1/4" x 11-1/4". We thought you might like to know that.

Stephen A. Walther
Publisher

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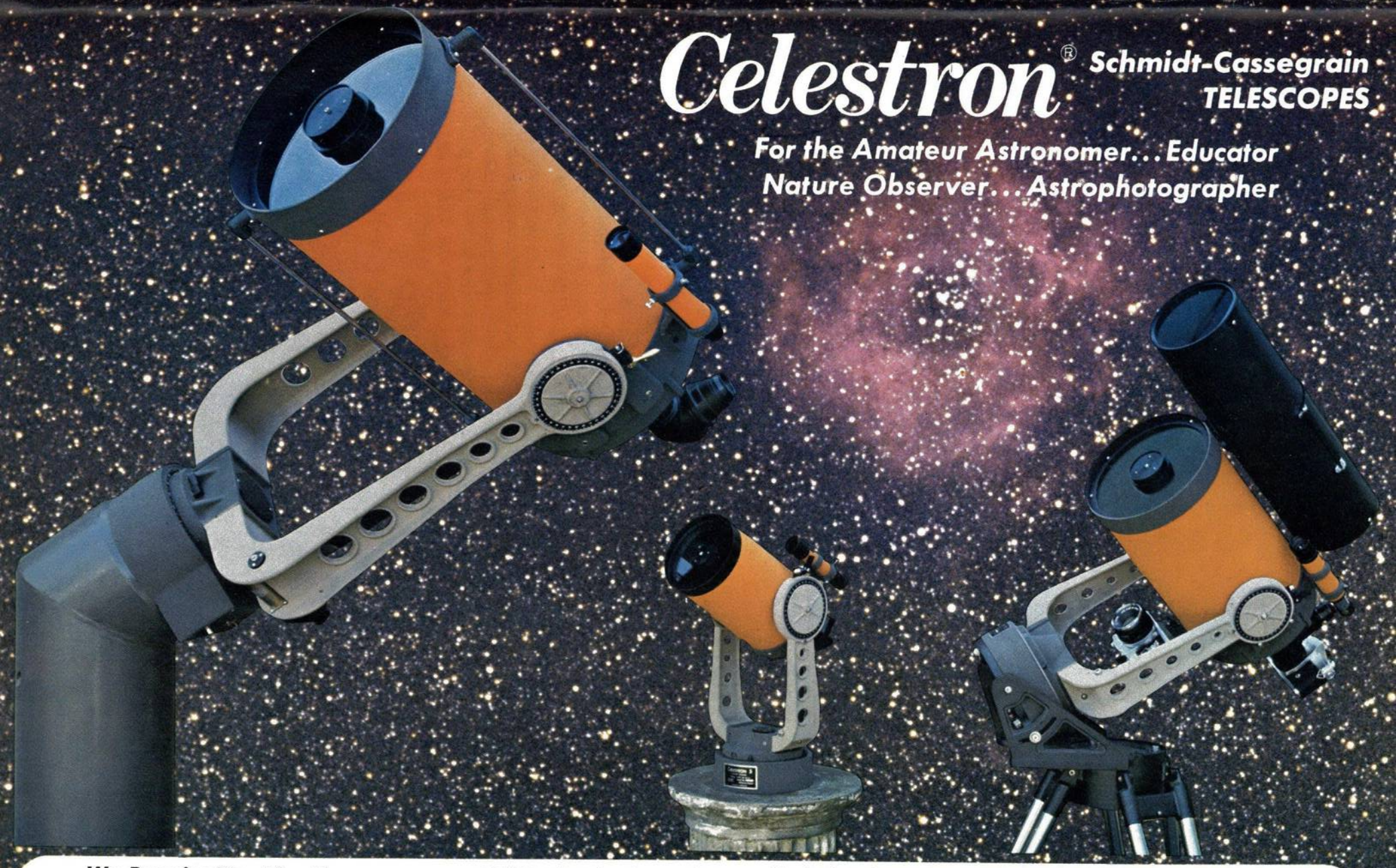

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Background Photo — The Rosette Nebula, Celestron 5½-in. Schmidt Camera

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